Woolgoolga to Ballina Pacific Highway Upgrade

Threatened Frog Monitoring Annual Report 2019/20

Version 3.0

NSW GOVERNMENT

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The client (TfNSW) may only use this document for the purposes for which it was commissioned. This report relies upon data, surveys, measurements and results based on a short-term objective study in response to a brief prepared by PacificComplete. Although conclusions have been based on the available data at that time, some professional judgement has been applied in reaching these conclusions due to the temporal limitations arising from the dynamic nature of available information, legislation, schedules, individual species and associated habitats. Every attempt has been made to ensure the accuracy and objectivity of the report's findings, conclusions and recommendations. Lewis Ecological Surveys does not accept responsibility for its use beyond the scope of works.

……..
Ben Lewis
(B. Applied Science Hons)

…12th December 2020……

Date

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Ben Lewis (Lewis Ecological Surveys) – Field Surveys, Report Author and Report Review.

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Chris Thomson (Jacobs) – Project management and review.

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1.0 INTRODUCTION

1.1 Project Overview and Background to this Monitoring

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

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

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

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

2.0 STATUS OF THE MONITORING PROGRAMS

This report covers the following monitoring periods:

- Giant Barred Frog monitoring program performed during the operational phase in Year 5 for Sections 1 and 2. This is the third year of operational monitoring;
- Wallum Sedge Frog monitoring program in Year 3 of the construction phase in Sections 8, 9 and 10. This is the third year of construction monitoring; and
- Green-thighed Frog monitoring program schedule for Year 5 performed during the operational phase for Sections 1 and 2 but only Year 4 of the construction phase in Sections 3, 6 and 7. This is the third year of operational monitoring in Section 1 and 2 but the fourth year of construction monitoring in Section 3, 6 and 7.

3.0 GIANT BARRED FROG – *MIXOPHYES ITERATUS*

3.1 Species Profile

3.1.1 Description of the Subject Species

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

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

Giant Barred Frog tadpoles are large and grow to over 100 mm in length. They are deep-bodied and ovoid, with a tail length twice that of the body. The tadpole's eyes are dorsolateral. The tadpoles are coloured yellow-brown above with dark spots and a dark patch at the base of tail. The underside is silver-white. The intestinal mass is obscured but the heart and lungs are visible from below (except near metamorphosis). The tail is thick and muscular (Anstis 2002). Fins are low and opaque with dark flecking (except the anterior half of the ventral fin; Meyer *et al.* 2001).

3.1.2 Distribution

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

3.1.3 Habitat and Ecology

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

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

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

3.2 Survey Methods

Field surveys were performed in accordance with the Threatened Frog Species Management Plan (RMS 2015). The exception was Site 2 where the transects were extended a further 500 m to 1 km in length at Dirty Creek (impact) and Pigeon Gully (control) following the recommendation from Year 3 sampling (Lewis 2018). The following details the areas surveyed along with the timing of field surveys and how the data were treated or analysed.

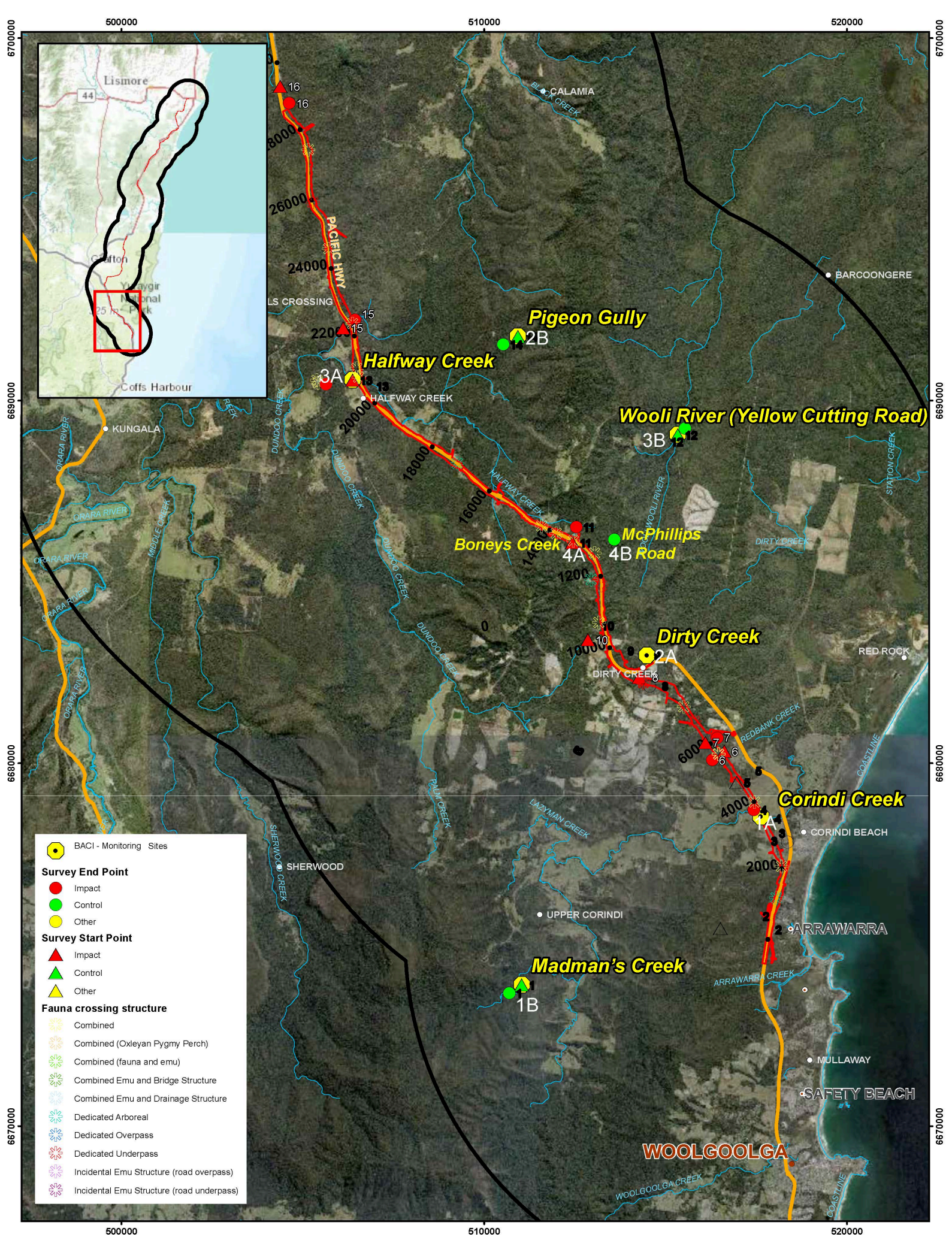
3.2.1 Site Selection and Treatment Design

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

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

3.2.2 Timing of Surveys

Frog surveys were performed in a manner that was consistent with the Threatened Frog Management Plan (RMS 2015). Sampling occurred in summer and autumn 2020 when there had been 10 mm of rainfall in 24 hours over the past 7 days and ambient air temperature was close to or ideally exceeding 18^{o}C. Sampling between surveys was extended to 50 days to improve on temporal independence between the first and second survey (Table A1).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510000
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Lismore
44
Clarence Valley
Coffs Harbour
Yuraygir National Park
BACI - Monitoring Sites
Survey End Point
Impact
Control
Other
Survey Start Point
Impact
Control
Other
Fauna crossing structure
Combined
Combined (Oxleyan Pygmy Perch)
Combined (fauna and emu)
Combined Emu and Bridge Structure
Combined Emu and Drainage Structure
Dedicated Arboreal
Dedicated Overpass
Dedicated Underpass
Incidental Emu Structure (road overpass)
Incidental Emu Structure (road underpass)
PACIFIC HWY
Pigeon Gully
2B
Halfway Creek
3A
Wooli River (Yellow Cutting Road)
3B
Boneys Creek
4A
McPhillips Road
4B
Dirty Creek
2A
Corindi Creek
1A
Madman's Creek
1B
CALAMIA
BARCOONGERE
KUNGALA
HALFWAY CREEK
RED ROCK
CORINDI BEACH
SHERWOOD
UPPER CORINDI
ARRAWARRA
MULLAWAY
SAFETY BEACH
WOOLGOOLGA
ORARA RIVER
DUNDOO CREEK
HALFWAY CREEK
WOOLI RIVER
DIRTY CREEK
REDBANK CREEK
COASTLINE
LAZYMAN CREEK
PALM CREEK
SHERWOOD CREEK
ARRAWARRA CREEK
WOOLGOOLGA CREEK
STATION CREEK
MIDDLE CREEK
BLACK CREEK
LEWIS ECOLOGICAL
Source: Aerial Photo: © Land and Property Information (a division of the Department of Finance and Services) 2012 Giant Barred Frog Monitoring Sites: Lewis Ecological 2014 Project Boundary & Chainages: RMS 2013
Disclaimer: This plan is based on or contains data provided by others. GeoView gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
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0 990 1,980 2,970 3,960
Meters
A4 Scale 1:125,000
Coordinate System: MGA56 Projection: Transverse Mercator
Project Boundary
10km Project Buffer
Arterial Road
Watercourse
Giant Barred Frog
(Mixophyes iteratus)
Monitoring Sites

3.2.3 Frog Surveys

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

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

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

3.2.4 Abiotic Data

The following abiotic variables were collected during the survey:

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

3.2.5 Monitoring of Connectivity Structures

Three connectivity structures were identified for monitoring and include the following:

- Bridge over Corindi Creek (62 m) at ch. 3600;
- Culvert at Boneys Creek (3 x 3 m; 100m) at ch.13310, and
- Bridge over Halfway Creek (57 m) at h. 20780.

No connectivity structure was identified for monitoring at Dirty Creek as the population and suitable habitat is restricted to the downstream side of the carriageway.

Sampling for frogs was performed in the same manner as described above. The use of PIT tags enables the location of the frog to be documented and approximately what distance upstream or downstream from the carriageway along with what side of the stream bank it was captured on. Demonstrated use of the structure has been defined as documented evidence that a recaptured frog has moved beneath the carriageway.

3.2.6 Monitoring of Riparian Revegetation

Riparian revegetation monitoring was performed where planting beds were located within 30 m of the water course at Corindi Creek, Boneys Creek and Halfway Creek. Planting beds were not considered if they occurred on the carriageway side of the permanent frog fence. At each of the planting beds, the proportion of failed plantings was estimated. This could be done due to the configuration or uniformity used at most of the planting beds. Total weed coverage was also estimated as a total percentage cover of the revegetation area. At this time, the rehabilitated stream bank was visually inspected for signs of instability and notes taken on the types of materials used. This information would then be used to assess the overall performance of the riparian rehabilitation program outlined in the Threatened Frog Management Plan.

3.3 Year 5 (Operational Year 3) Monitoring Results

3.3.1 Frog Population

Giant Barred Frogs were recorded at 7 (88%) of the 8 sites including Site 1A (Corindi Creek), 1B (Madmans Creek), 2A (Dirty Creek), 3A (Halfway Creek), 3B (Yellow Cutting Road), 4A (Boneys Creek) and 4B (McPhillips Road-Upper Halfway Creek; Figure 3-1). Frogs were not recorded from the reference Site 2B (Pigeon Gully; Table 3-1).

Sampling recorded 188 frogs including adults, sub adults and juveniles while dip-netting captured 40 tadpoles, a reflection of the ideal breeding conditions. A summary of each monitoring site is provided below.

- Corindi Creek (Site 1A) – 41 frogs comprising 31 adults, six sub adults and four juveniles. Eleven of the frogs were recaptures from previous monitoring events and include the following:
    - Adult male (735A0AF) that continues to use habitat around 20-60 m upstream from the carriageway with captures recorded in Year 2, 3, 4 and 5.
    - Adult male (7357972) that has remained around 200 m upstream with captures in Years 2, 3, 4 and 5.
    - Adult female (7356F45) that remains approximately 150 m upstream with captures in Years 2, 3, 4 and 5.
    - Adult female (735D21B) that previously moved from approximately 80 m downstream in Year 3 to 70 m upstream in Year 4. During this round of monitoring, she was captured 50 m upstream from the north bound bridge but has been previously captured downstream.
    - Adult male (73567T9) that was first captured as a sub adult in Year 3. During this round of monitoring, the frog was captured around 100 m downstream on the southern bank and remains in the same area.
    - Adult male (7352C37) that was captured 100 m upstream on the northern bank. This frog was previously captured in this general vicinity back in Year 3.
    - **Adult female (7352A54) that was captured 30 m downstream on the southern bank. This frog has been previously captured around 50 to 100 m upstream but has now moved downstream. For this to have occurred, the frog must have moved beneath the newly constructed bridges and through the regenerating landscape plantings. Given her affinity to the southern bank, she is likely to have moved through that particular area. This may have been in response to flood events in late summer and autumn 2020.**
    - **Adult male (735BEC7) that was previously captured 100 m upstream was recorded at edge of rehabilitated area among the Lomandra plantings. This demonstrates the rehabilitated areas may provide at least part of some frogs maintained territory other than just a movement corridor.**
    - **Adult male (735A0AF) that was captured among the Lomandra plantings. In the past, this frog has maintained a territory just upstream of the carriageway.**
    - **Adult female (73567C6) was captured 20 m upstream on the northern bank. This frog was previously recorded in Year 3 around 80 m downstream on the southern bank. For this to have**

occurred, the frog must have travelled through the rehabilitated area beneath the twin bridges and crossed the creek at some stage.

  - Adult male (735787A) that was captured between the first and second round of Year 5 monitoring. On both occasions, the frog was around 100 m upstream on the northern bank.

- Madmans Creek (Site 1B) – 31 frogs comprising 16 adults, 11 sub adults and four juveniles. Seven frogs were recaptures from the previous monitoring events performed in Year 4 with one frog, a large female a recapture from Year 2;
- Dirty Creek (Site 2A) – Nine frogs comprising five adults, two sub adults and three juveniles. All captures were restricted to the bottom 250 m of the monitoring transect. There were two recaptured adults from Year 4 and a sub adult from the earlier summer sampling. In each case, frogs had not moved more than 50-70 m.
- Pigeon Gully (Site 2B) - No frogs were recorded during Year 5;
- Halfway Creek (Site 3A) – 55 frogs comprising 40 adults, 12 sub adults and three juvenile. Eight of these frogs were captures were from previous monitoring events and include the following summary:
  - Adult female (735B8F8) captured in Year 3 and 4 was at the edge of rehabilitated planting areas that was formally the construction footprint.
  - Adult male (735C3E3) captured in Year 3 around 120 m downstream has moved further downstream to around 160 m in Year 5.
  - Adult male (735431F) from Year 2 and Year 4 remains upstream but has moved further downstream to almost the edge of the rehabilitated area on the southern bank.
  - **Adult female (73582EC) from Year 2 has moved from just upstream outside of the construction zone to the revegetated area on the northern bank in Year 4. During this round of monitoring she was first captured on the northern bank in the construction zone which has been rehabilitated with plantings and stabilised with jute mesh. During the second round of sampling in late April, she was recaptured around 10 m downstream side of the construction zone. For this to have occurred, the frog has moved beneath both bridges and through the rehabilitated areas to the downstream side of the carriageway.**
  - Adult male (735B008) that has been previously captured in the construction zone was again captured in the construction zone on the southern bank. This frog has maintained a territory in and around the construction zone since Year 2.
  - Adult male (7359655) from Year 4 has remained at the downstream edge of the rehabilitated area where he was captured during the first summer survey in 2020 but not during the autumn survey.
  - Adult male (735CF3D) first captured upstream as a sub adult in Year 3 was recaptured as an adult in Year 5 around 60 m upstream of the carriageway.
  - **Adult female (735C00A) that was captured for the first time in Year 3 and recaptured again in Year 5 within the rehabilitated plantings, just to the east of the southbound bridge. This frog previously inhabited the retained riparian vegetation downstream of the carriageway and has**

recently moved up into the rehabilitated plantings. This represents another example of habitat connectivity that has been restored for Giant barred Frogs at this location.

Nine adult and one sub adult frog were recorded using the revegetated riparian zone and included both males and females found on both the northern and southern banks. Two frogs on the southern bank were using the stone pitching a few metres from the water;

- Yellow Cutting Road (Site 3B) – 34 frogs with 18 of these adults, nine sub adults and seven juveniles. There were seven recaptures at this site including five adults and two sub adults. Eight tadpoles were dip-netted during the autumn survey in the bottom half of the transect;
- Boneys Creek (Site 4A) – Four frogs comprising three adults and a sub adult. There were a single recapture, from the earlier summer survey and no frogs were recorded on the upstream side of the carriageway (i.e. the top half of the transect); and
- McPhillips Road (Site 4B) – Four frogs comprising two young adults and two sub adult frogs. There were no recaptures.

In accordance with recommendations outlined in the baseline surveys, captured frogs were microchipped for individual verification during later sampling and to assist in the connectivity structure monitoring. Eighty-seven (87) frogs were micro-chipped, whilst the remainder were either recaptures, had simply eluded capture or were too small (<40 mm snout-vent) to insert microchips.

3.3.2 Connectivity Structure & Permanent Frog Fence Monitoring

Corindi Creek (Site 1A) – Eleven frogs were recaptures from previous construction monitoring events. Two female frogs have moved from remnant riparian habitat on one side of the carriageway to remnant riparian habitat on the other side since they were last captured. Frog (7352A54) was captured 30 m downstream on the southern bank during this round of monitoring but had been previously caught 50-100 m upstream. For this to have occurred, the frog must have moved beneath the newly constructed bridges and through the establishing landscape plantings. Given her affinity to the southern bank, she is likely to have moved through that particular area. Frog (73567C6) on the other hand was captured 20 m upstream on the northern bank. This frog was previously captured in Year 3 around 80 m downstream on the southern bank. For this to have occurred, the frog must have travelled through the rehabilitated area beneath the twin bridges and in crossed the creek at some stage. Two male frogs were also recorded in the rehabilitation areas, with an adult male (735BEC7) recorded in Year 5 from among the establishing Lomandra plantings whilst previous captures have shown the frog up to 100 m upstream. The second male frog (735A0AF) has a similar capture history where it previously maintained a territory upstream but was captured within the establishing Lomandra plantings in Year 5.

Figure 3-2. Giant Barred Frog abundance recorded during baseline and construction/operational monitoring Years 1-5 according to age class.

Table 3-1. Summary of the Giant Barred Frog Year 5 surveys for BACI Sites 1-4. Numbers in parentheses represent baseline abundance.

	Year 5 (Surveys)					
BACI Site	**Date**	**Total Number Frogs Captured**	**Calculated Mean No. of Frogs Per 500 m**	**Frog Management Mitigation Observed or Recorded**	**General Comments**	**Presence of Giant Barred Frogs Confirmed in Baseline Survey**
1A ch.3600 (Corindi Creek)	15th January 2020 20th April 2020	41	20.5 (10)	i. Permanent frog fence installed as per the requirements of the TFMP for 2:1 batters, however, number of potential breach points/defects remain as per Year 4. ii. Bridges installed to maintain habitat connectivity. iii. Revegetation and bank stabilisation works observed. iv. Frogs captured from within the rehabilitated works area. v. Frogs recorded moving from one side of the carriageway to the other side. vi. Numbers of frogs recorded is higher than the baseline surveys.	i. Demonstrated habitat connectivity restored with two adult females moving both upstream and downstream in Year 5. ii. Two male frogs have moved from upstream to within establishing plantings suggesting may form part of their territory. iii. Frogs recorded both upstream and downstream of the Upgrade. iv. Frog fence contains a number of breach points. Only likely to present a problem during flood flows that manage to breach the banks of the main channel as frogs would be pushed away from their normal occupation areas which as the data shows is <10 m from water's edge (Plate 3-8). v. Higher number of tadpoles recorded than previous monitoring which suggests improved breeding conditions.	Yes
1B (Madmans Creek)	15th January 2020 20th April 2020	39	19.5 (7)	Outside works footprint.	i. Site periodically retracts to a series of pools, or dries as was the case for much of the transect leading up to the surveys. ii. Frog counts are markedly higher than the baseline surveys which had been performed during largely dry seasonal conditions.	Yes
2A ch. 8500 (Dirty Creek)	16th January 2020 21st April 2020	13	6.5 (5)	i. Rehabilitation upstream observed and outside or above monitoring transect.	i. Frogs captured along southern part of transect following absences in Year 3. ii. Frog numbers now higher than baseline survey with evidence of recruitment. iii. Habitat connectivity less of a concern as Project bisects edge of known habitat and may not isolate it.	Yes
2B (Pigeon Gully)	16th January 2020 21st April 2020	0	0 (1.5)	Outside works footprint.	i. Ongoing absence at site during Year 5 monitoring. ii. Riparian areas burnt during wild fire events in December 2019.	Yes
3A ch.20800 (Halfway Creek)	17th January 2020 23rd April 2020	64	32 (0.5)	i. Frogs recorded in the rehabilitated zones during summer and autumn surveys. ii. Permanent frog fencing remains intact. iii. No frogs recorded on the road side of the permanent frog fence. iv. Frogs recorded on both sides of the carriageway.	i. Demonstrated habitat connectivity restored with two adult females moving through the rehabilitated areas in Year 5. ii. Three male frogs have moved into the rehabilitated area with plantings which suggests also provides suitable habitat for frogs to maintain territories. A further seven frogs recorded inhabiting rehabilitated area including use of southern bank stone pitching.	Yes

BACI Site	Year 5 (Surveys)			Frog Management Mitigation Observed or Recorded	General Comments	Presence of Giant Barred Frogs Confirmed in Baseline Survey
	Date	Total Number Frogs Captured	Calculated Mean No. of Frogs Per 500 m			
					iii. Frog fence contains a number of breach points around the stone abutments. Only likely to present a problem on south bound lanes. iv. Planting beds beneath the bridges are failing with increased losses exceeding 40%.	
3B (Yellow Crossing Road)	17th January 2020 23rd April 2020	41	20.5 (29.5)	Outside works footprint.	i. Fewer frogs than recorded during the baseline survey but increase in frog numbers from Year 3 and 4. ii. Frog numbers may have been impacted from fuel reduction burn in 2016 that burnt parts of southern transect.	Yes
4A ch.13300 (Boneys Creek)	21st January 2020 24th April 2020	5	2.5 (0)	i. Permanent frog fencing observed. ii. Two cell box culvert provides connectivity for tadpoles.	i. No frogs recorded on upstream side to date and not previously mapped as known habitat. ii. Increased sediment in culvert provided sand bars and has improved suitability of the culvert for frog connectivity.	No
4B (McPhillips Road)	21st January 2020 24th April 2020	4	2 (0)	Outside works footprint.	i. Frog numbers continue to mirror the impact monitoring transect (Boneys Creek) and both exceed the baseline survey. ii. Frogs tend to congregate around one to two pools above McPhillips Road.	No

Surveys of the permanent frog fence found no Giant Barred Frogs on the carriageway side of the fence. There were however, a number of potential breach points for frogs to move up onto the highway, namely no frog fence installed between the bridges, numerous gaps at the bottom of the frog fence along with the fence return installed the opposite way (Plate 3-2). Surveys are required during a flood event to assess if frogs are likely to access these areas as they seek refuge from flood waters.

Plate 3-2. Missing frog exclusion fence at Corindi Creek on the northern abutment (left) and frog fence return facing the opposite way along with numerous holes at the bottom of the fence (right).

Halfway Creek (Site 3A) – Eight captures were from previous monitoring events and there was evidence for the first time that frogs have moved beneath the two bridges with two adult females moving from remanent riparian habitat on one side of the carriageway to remanent riparian habitat on the other side. Some adult male frogs have established territories within these rehabilitated areas while a further seven frogs were found using the rehabilitated area on both the northern and southern banks (Plate 3-3). On the southern bank, two frogs were observed using the stone pitching a few metres from the water's edge.

No barred frogs were found along the carriageway side of the permanent frog fence. During these inspections, some of the installed frog fence is not consistent with the designs and was found to contain a large gauge mesh size that would only prevent larger barred frogs from accessing the carriageway, or trap frogs as they attempt to move through it. A targeted survey during a flood event would be useful to determine where frogs move to as they retreat from flood waters.

Plate 3-3. Adult male frog using the southern bank rehabilitated area and female using the northern bank planting bed**.**

Boneys Creek (Site 4A) – There was no recaptures during this round of monitoring. No Giant Barred Frogs were found on the carriageway side of the fence as part of permanent frog fence surveys. There are however, a number of potential breach points where the bottom of the fence should connect with the natural or reinstated ground. These breaches have been fixed by TfNSW during works in August 2020.

3.3.3 Riparian Revegetation Monitoring

Riparian revegetation monitoring took place where plantings occur as part of the monitoring transect and integrate with habitat connectivity structures such as the bridges at Corindi Creek and Halfway Creek, or the culvert at Boneys Creek. A summary for each site is provided below.

Corindi Creek - Planting failures were measured at 8% (Plate 3-4). Total weed coverage was measured at 10% and limited to the outer edges of planting beds. This is within the accepted tolerance level of 10% in the first year and 20% over the three year maintenance program. Some removal of native trees (i.e. non-fragibles growing too close to the bridge structures) has taken place and these have been stockpiled on some of the Lomandra plantings (Plate 3-4).

Past bank erosion has been addressed on the southern stream bank with large stone pitching (Plate 3-4). On the northern downstream bank, some sand has been deposited over the plantings beds as a result of flooding in late summer and autumn (Plate 3-4). The area that had been treated with tree stumps to prevent further erosion remains intact.

Plate 3-4. Planting beds impacted from stockpiling of trimmed trees on northern bank (left) and log/stump treatment remains intact and reducing erosion (right).

Halfway Creek (3A) - Planting failures were somewhat variable at this site and averaged 28%. On either side of the bridges, failures were measured at 5% whilst those beds beneath the bridges were measured at 40% and receive little or no natural rainfall and reduced sunlight (Plate 3-5). The acceptable tolerance level of 10% in the first year and 20% over the three year maintenance program has been exceeded with these planting beds beneath the bridge. Total weed coverage was measured at 15% and became more prevalent on the outer edges of the planting beds, particularly on the northern bank upstream of the south bound bridge (Plate 3-5). Here, most of the weeds are perennial grasses and annual herbaceous ground covers. There was no sign of current bank erosion with stone pitching used as part of rehabilitating the southern bank. Both stream banks remain intact and suitable for installed plantings.

Plate 3-5. Planting beds upstream of the bridge with 5% loss (left) versus planting beds with 40% loss beneath the bridge (right) with no rainfall.

Boneys Creek (4A) - Planting failures were measured at 18%. Total weed coverage was measured at 25% and became more prevalent on the outer edges of the planting beds. This is within the accepted tolerance level of 10% in the first year

and 20% over the three year maintenance program. There are signs of erosion in the upstream part of transect with sediment being deposited within the culvert structure (Plate 3-6). This may actually improve habitat connectivity for frogs as the structure was permanently inundated but now had a number of sand islands.

Interestingly, most of the riparian zone consists of large aggregate with only some localised planting beds or the use of frangible mixes whilst some bare earth or mulched areas with no tube stock planting is now benefiting from passive regeneration (Plate 3-6).

Plate 3-6. Planting beds upstream of the bridge (left) and sediment in box culvert improving habitat connectivity for Giant barred Frogs (right).

3.4 Discussion

Monitoring during Year 5 revealed a trend not unlike that in Year 4 with frogs remaining absent at Pigeon Gully but present at all other locations. All sites with frogs showed some form of recruitment into the population in the form of juveniles or sub adults. In many cases, more tadpoles were recorded than at any other stage of the monitoring program, probably a direct link to heavy rainfall and associated flooding which provided ideal breeding conditions. A discussion for each of the four BACI sites is provided below.

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

The numbers of adult frogs at the impact site along Corindi Creek continues to exceed the pre construction baseline density of 10 frogs per 500 m of riparian habitat with a mean of 20.5 frogs per 500 m of riparian habitat. Importantly, more sub adult and juvenile frogs were recorded than previous monitoring events indicating some of the more prominent rainfall events over the past two seasons provided successful breeding at this location. The detection of tadpoles indicates that frogs bred following the rainfall between mid January and late March 2020. Frogs remain distributed on both sides of the carriageway, however, more frogs tend to occur upstream which has always been the case.

The installed or operational mitigation at this site includes twin bridges, permanent frog fencing installed high on the batter of the carriageway formation and some strategic rehabilitation around the bridge abutments, along with some scour protection and stone pitching. Of the 11 recaptures during this round of monitoring, two were female frogs that had moved either downstream or upstream from their last capture in Year 2, 3 or 4. For this to have occurred, the frogs would have moved beneath the twin bridges and through the area of rehabilitated riparian habitat. This represents the second consecutive occasion with which frogs have utilise the mitigation provided and thus demonstrate habitat connectivity has been restored. A third such event during another round of monitoring is now required before the monitoring program can be finalised.

The control or reference site along Madmans Creek continues to show more marked variation in frog numbers. During this round of monitoring, the mean number of frogs was almost three times that of the baseline survey and included a number of adults, sub adults and juveniles whilst a relative large number of tadpoles were dip-netted. Water levels at this site fluctuated more so during this round of monitoring with the first survey occurring during lower flows than the later April survey, but this tends to stimulate breeding at this site. Importantly, both sites showed increases and the deviation hasn't exceeded 25% in terms of performance measures.

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

The original transect length of 500 m was reinstated at this site following the detection of frogs along Dirty Creek in Year 4. Frog numbers were on average higher than the baseline survey at Dirty Creek and there was a couple of recaptures from the Year 4 survey, but none from earlier monitoring. Both adults, sub adults and juveniles were captured during this round of monitoring indicating recruitment into the recovering population. Frogs do however, remain concentrated in the lower half of this transect.

No frogs were recorded at the nearby control site at Pigeon Gully. Just prior to monitoring, a wild fire had burnt through parts of the site but its overall impact is thought to have had little consequence to the data as frogs have only ever been recorded some years earlier during the baseline survey (Lewis 2014). Monitoring during an extended period of wet weather may be the only real opportunity to determine whether frogs have disappeared from this part of the Halfway Creek catchment.

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

Halfway Creek continues to provide positive results with a population size or frog density well in excess of the baseline survey and evidence of the rehabilitation areas providing habitat and restoring habitat connectivity. Frogs were again recorded along the full transect gradient and for the second consecutive year, a number of adult males and females were using the rehabilitation areas (Plate 3- 5). For the first time, frogs were recorded moving from remanent riparian habitat on one side of the carriageway to remanent riparian habitat on the other side with one female moving upstream and the other downstream. Male frogs may be less likely to make the complete passage as they tend to occupy smaller home

ranges or maintain territories along 50-100 m of riparian habitat. One of the recaptured male frogs has maintained his territory within the rehabilitated area on the southern bank. This indicates the rehabilitated areas are now providing habitat for Giant barred Frogs and not just movement habitat or for short term forays as part of foraging or breeding movements. More than 100 frogs have now been marked at this location since monitoring began back in 2016.

The reference site at Yellow Crossing Road in the upper Wooli River catchment continues to produce lower numbers of frogs than it did during the baseline surveys. During this round of monitoring, more frogs were recorded in this area than they had in recent years and it is unclear whether a fuel reduction burn that burnt part of the transect in 2016 reduced frog numbers. The return to a late wet summer and autumn is likely to have improved breeding opportunities and with this frog numbers are likely to increase of the next couple of years.

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

Monitoring at both Boneys Creek and Upper Halfway Creek continue to yield small numbers of frogs that exceed the density recorded in the baseline survey (Lewis 2014). At Boneys Creek, this round of monitoring produced three adults and a sub adult all from the downstream side of the monitoring transect where frogs tend to concentrate around a permanent pool. Meanwhile, frogs continue to remain absent from the upstream side of this transect which is still regarded as marginal habitat. The deposited sand and soil in the culvert has improved connectivity for frogs as these now act as sand bars and a terrestrial passage.

The reference site of Upper Halfway Creek adjacent to McPhillips Road produced two young adult frogs and two sub adults. Frogs were recorded in the upstream section of the transect adjacent to McPhillips Road,, an area which appears to be the upper reaches of the Halfway Creek Giant Barred Frog population.

The following section compares the Year 5 monitoring data against the performance prescriptions outlined in the Threatened Frog Species Management Plan (RMS 2015).

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 includes the population monitoring, the underpass structure monitoring and riparian habitat monitoring where revegetation works have taken place. Each of these are discussed in the sections below and summarised in Table 3-2.

3.5.1 Population Monitoring

Both declines and increases were recorded across the monitoring sites and this has been summarised in Table 3-3. Increases were recorded at Corindi Creek (Site 1A), Madmans Creek (Site 1B), Dirty Creek (2A), Halfway Creek (Site 3A), Boneys Creek (Site 4A) and McPhillips Road (Site 4B). Some of these increases were in the order of 60 times greater than the baseline survey (Halfway Creek), and in doing so, it confirms the large scale variability expected for r selected species which undergo marked fluctuations in population size. At sites with lower densities, this variability can result in counts of zeros as was the case at Dirty Creek in Year 3 but has now recovered to the point it is now 30% higher than the baseline survey (Table 3-3). Importantly, frogs have returned to this section of the creek for the second consecutive year and there is evidence of recruitment into the population along with continued breeding. The paired control site at Pigeon Gully has continued to record an ongoing absence of Giant Barred Frogs for the past five years of monitoring, and despite a change in sampling methods, a population has not been found. At this site, sampling may only yield frogs once there is a return to average or above average rainfall over the spring, summer and autumn months, something with which the first part of 2020 has provided.

Table 3-3. Mean number of Giant Barred Frogs (inclusive - adults, sub adults, juvenile) during the construction and operation in Years 1-5.

Sampling Year	Corindi Creek (Impact)	Madmans Creek (Control)	Dirty Creek downstream (Impact)	Pigeon Gully (Control)	Halfway Creek (Impact)	Yellow Cutting Road (Control)	Boneys Creek (Impact)	McPhillips Road (Control)
	1A	1B	2A	2B	3A	3B	4A	4B
GBF Base	10	7	5	1.5	0.5	29.5	0	0
GBF Year 1 (mean count)	5	4.5	2.5	0	4	1.5	0	0
GBF Year 2 (mean count)	13	17	1.5	0	30.5	12.5	1	0.5
GBF Year 3 (mean count)	12	17	0	0	17.5	9.5	2	4
GBF Year 4 (mean count)	13.5	12.5	2	0	18	7.5	1	1.5
GBF Year 5 (mean count)	20.5	19.5	6.5	0	32	20.5	2.5	2
Increase (%)	105%	178%	30%	-	6300%	-	100	100
Decline (%)	-	-	-	absent	-	31%	-	-

3.5.2 Structure Monitoring

Twenty-three (20) frogs captured during Year 5 were recaptures from previous monitoring events and provide opportunities to evaluate the habitat connectivity role of bridges and underpasses for Giant Barred Frog[1]. A summary for each site is provided below.

Corindi Creek (Site 1A) – Two adult female frogs were recorded moving from remnant riparian habitat on one side of the carriageway to remnant riparian habitat on the other side. This included one frog moving downstream with the capture data showing an affinity to the southern bank. Meanwhile, a second female frog was recorded moving upstream beneath

[1] Three captures from Dirty Creek not included due to no connectivity structures associated with the monitoring transect.

the bridges and crossing the creek at some stage. Two male frogs were also recorded within the rehabilitation areas indicating these areas now provide some habitat value other than just habitat connectivity. This is the second consecutive year that frogs have been recorded moving from one side of the carriageway to the other side and the first year for frogs residing within the rehabilitated plantings.

Surveys along the permanent frog exclusion fence found no barred frogs on the road side, however, there were a number of potential breach points, namely where the fence travels over uneven ground such as the bridge abutments covered with large aggregate along with the fact it has been recessed along the ground in the opposite and incorrect way (Plate 3-2). Furthermore, the frog fence between the two carriageways is missing thus enabling frogs to potential access the carriageway (Plate 3-2). The risk of this actually occurring is very low until a flood event when frogs move away from the inundated riparian habitat and seek refuge at higher points. Flooding during the 2020 season shows that much of the stone pitching was inundated on at least one occasion (Plate 3-7).

Plate 3-7. Flood debris showing height of flood waters during 2020.

Dirty Creek (Site 2A) – No connectivity structures are relevant to this monitoring transect which focuses on downstream impacts as the highway did not bisect the known population. Similarly, no permanent frog fencing is present.

Halfway Creek (Site 3A) – There were eight recaptures from previous surveys during this round of monitoring. Two adult female frogs had moved from remnant riparian habitat on one side of the carriageway to remnant riparian habitat on the other side of the carriageway. One frog had moved upstream whilst the other had moved downstream. These two records represents the first completed passage through the rehabilitated area which coincides with the third year of operational monitoring.

Two male frogs were also recorded within the rehabilitated areas and have moved upstream from their last capture. A further seven adult frogs and one sub adult were recorded within the rehabilitated areas of jute mesh and plantings indicating continued success of habitat restorations for the second consecutive year (Plate 3-3).

Surveys of the permanent frog exclusion fence found no barred frogs on the road side, however, there were a number of potential breach points, namely where the fence travels over uneven ground, particularly the stone pitching used on the bridge abutments along with the fact that an incorrect frog fence design with a larger aperture has been used on the northern abutment. A number of these breach points were fixed by TfNSW in August 2020. In reality, these areas would only be used by barred frogs during flood events as individuals move away from the stream bank. As there are a number of frogs starting to inhabit these rehabilitation areas, a targeted survey during such a flood event would qualify whether these frogs seek refuge around these abutments.

Boneys Creek (Site 4A) – There was a single recapture from the earlier summer monitoring event in autumn. This frog remained around 80 m downstream of the carriageway within 10 m of its original capture. To date, no frogs been recorded on the upstream side of the carriageway. Surveys of the permanent frog exclusion fence found no barred frogs on the road side, however, there were a number of potential breach points, namely where the fence travels over uneven ground. A number of these breach points were fixed by TfNSW in August 2020.

3.5.2 Riparian Revegetation Monitoring

Corindi Creek (Site 1A) - Planting failures were measured at 8% which is within the accepted tolerance level of 10% in the first year and 20% over the three year maintenance program. Total weed coverage was measured at 10% and limited to the outer edges of the planting beds. This is within the accepted tolerance level of 30% cover.

Past bank erosion has been addressed with some large stone pitching and this has improved the stability for revegetation works (Plate 3-6). On the northern bank, some sediment has been deposited on the downstream side of the southbound bridge piers and has resulted in some planting losses (Plate 3-4). Meanwhile, the tree stumps used to reduce erosion remains intact and considered effective at stabilising this part of the stream bank (Plate 3-4).

Halfway Creek (Site 3A) - Planting failures were measured at 28% and exceed the 20% over the three year maintenance period. Most of these losses were attributed to those planting beds beneath the bridges that don't receive natural rainfall, calculated during this round of monitoring at 40% compared to 5% at the beds adjacent to the bridges (Plate 3-6). There is some evidence of third party damage as a result of vehicles, bikes and pedestrians accessing these areas. Restricting access may limit further damage.

Total weed coverage was measured at 15% and falls within the accepted 30% ground cover tolerance. There was no sign of current bank erosion with some large aggregate used in the stone pitching as part of rehabilitating the southern bank.

Boneys Creek (Site 4A) - Planting failures were measured at 18% and fall within the accepted tolerance level whilst the total weed cover was measured at 25% and within the accepted 30% tolerance level. There was some minor signs of erosion associated with some longitudinal drainage on the upstream side of the carriageway and some tension cracking and minor slumping of fill sections off the south bound carriageway but neither have contributed to the sediment loads deposited in the culvert structure (Plate 3-7).

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

Triggers for corrective actions	Corrective actions	Relevance to Year 5 Giant Barred Frog Monitoring	Results of Year 5 Giant Barred Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Population Monitoring					
The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys. 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: • Number of Wallum Sedge Frogs per 100 m2 of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frog per Stage 1 survey (breeding survey) (as outlined in Section 4.3).	Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance. Investigate effectiveness of frog exclusion fencing immediately. Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation. 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.	Relevant	Increased numbers of Giant Barred Frogs recorded from all of the impact sites: - 1A (Corindi Creek), - 2A (Dirty Creek) - 3A (Halfway Creek); - 4A (Boneys Creek).	i. Natural fluctuations in population with some sites increasing and other decreasing.	Nil. .
Underpass Structure Monitoring					
The use of the structure by less than 1% of the estimated population size. Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.	Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified. Survey habitat adjoining the connectivity structures and undertake Landscape improvement (planting, weed removal) to improve habitat functionality. 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. Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.	Relevant	**Corindi Creek** (1A) – Two adult female frogs (7352A54 73567C6) recorded moving from one side of the carriageway to the other. One frog (73567C6) also crossing the creek. No barred frogs recorded on the road side of the fence. Dirty Creek (2A) – No structures relevant.	Corindi Creek – Suitable plantings and rehabilitation has provided habitat connectivity. Heavy January, February and March 2020 rains provided movement cues for movement and breeding. Boneys Creek – Habitat upstream is considered marginal with no known occurrences of frogs in this area. May require a season with average to above average rainfall to encourage broader movements. Additional monitoring following 2020 rains may prove worthwhile.	Nil.

Triggers for corrective actions	Corrective actions	Relevance to Year 5 Giant Barred Frog Monitoring	Results of Year 5 Giant Barred Frog Monitoring	Potential Contributing Factors	Corrective Action Required
			Permanent frog fencing not relevant at this location. Boney Creek (4A) – No frogs recorded on upstream side. No barred frogs recorded on the road side of the fence. Halfway Creek (3A) – Two adult female frogs (73582EC 735C00A) moved from upstream side of carriageway to downstream side. Ten frogs recorded in the rehabilitated areas on both sides of carriageway and stream bank. No barred frogs recorded on the road side of the fence.	Halfway Creek – Suitable plantings and rehabilitation has provided habitat connectivity. Heavy January, February and March 2020 rains provided movement cues for movement and breeding.	
Riparian Habitat Revegetation					
Greater than 10% of riparian plants have died after first 12 months of maintenance. Greater than 20% of riparian plants have died after three years of maintenance. Total weed coverage is more than 30% in revegetation areas.	Review maintenance schedule for revegetated areas immediately after trigger. Replace dead plants within one month of issue being identified. Increase weed control if required as soon as practicable or review control methods being used.	Relevant with all planting beds installed.	Corindi Creek – Planting failures - 8%. Total weed coverage – 10% and limited to outer edges of planting beds. Stream banks intact, sediment deposition on northern downstream bank has smothered some plantings.	Corindi Creek - Natural attrition rate of tube stock plantings combined with extended dry periods. Weeds to be expected as the interface with exotic pasture lands and along a lower order stream. Boneys Creek – Natural attrition rate of tube stock plantings	Nil.

Triggers for corrective actions	Corrective actions	Relevance to Year 5 Giant Barred Frog Monitoring	Results of Year 5 Giant Barred Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Bank erosion causes unforeseen revegetation area instability.	Install physical measures to halt bank erosion within one month of issue being identified.		Boneys Creek – Planting failures 18%. Weed coverage 25% with majority between the highway and service road and downstream side of service road culvert. Minor tension cracks on batters and minor scour in longitudinal drain but neither account for large sediment loads found in culvert. Halfway Creek – Planting failures - 28%. Total weed coverage – 15% and limited to outer edges of planting beds with perennial grasses and annual weeds. No bank erosion impacting on plantings.	combined with extended dry periods. Weeds to be expected at the interface with highway road verge and along a stream with agricultural enterprises in the catchment. Halfway Creek – Majority plant failures (40%) arisen from planting beds beneath bridges that don't receive rainfall and very little natural light. Outside of these areas, plant failures just 5%. Combination of design and possibly maintenance with little intervention during the 3 year period.	

3.6 Conclusions and Recommendations

Population monitoring during Year 5 continues to demonstrate the presence and viability of Giant Barred Frog populations bisected to accommodate the Woolgoolga to Ballina Upgrade. Since the baseline surveys in 2013 and 2014, frog populations at Corindi Creek, Halfway Creek and Boneys Creek have generally increased. At Dirty Creek, the population has undergone a constant state of fluctuation with some initial declines that culminated in an absence in Year 3 before recovering in Year 4, and increasing in Year 5 to the point that frog numbers are now higher than the baseline survey with evidence of ongoing recruitment into the population following captures of sub adults and juveniles. Meanwhile, the paired control site at Pigeon Gully has undergone a more notable decline where no frogs have been found since the initial baseline survey in 2014, despite increasing transect length to 1.5 km and some further targeted works downstream. This demonstrates that some frog populations may decline or disappear for reasons other than habitat disturbance.

At this stage of the monitoring program, more than 200 frogs have been micro chipped in and around where operational mitigation devices of bridges, culverts, permanent frog fencing and rehabilitation areas with frog commensurate plantings have been installed. During this third year of operational monitoring, two recaptured female frogs at Corindi Creek had moved from remnant riparian habitat on one side of the carriageway to remnant riparian habitat on the other side with one frog moving downstream and the other upstream. This is the second consecutive year that a frog has moved from one side of the carriageway to the other. In addition, two male frogs have shifted from remnant riparian habitat upstream to within the rehabilitated area, indicating that it now forms part of their territory. The restoration of riparian habitat connectivity is considered at an advanced stage where the majority of plantings have survived, there is little weed incursion and the stone pitching and strategic use of tree stumps have kept the stream banks stabilised. Surveys along the constructed frog fence extents at Corindi Creek found no Giant Barred Frogs on the road side and this has now been the case over the past three years.

Meanwhile at Halfway Creek, two female frogs were recorded moving from the upstream side of the carriageway to remanent riparian habitat on the downstream side. This is the first reported occurrence at this site despite five frogs using the rehabilitated areas in Year 4. During this round of monitoring, this number doubled to 10 frogs indicating riparian habitat connectivity is now at an advanced state and will continue to improve. This included a recaptured male which had been using the rehabilitated area in Year 4 indicating that it forms part of its usual habitat or territory. Surveys along the constructed frog fence extents at Halfway Creek found no Giant Barred Frogs on the road side and this has now been the case over the past three years.

Assessing the usefulness of habitat connectivity mitigation remains difficult at Boneys Creek as the field surveys are unable to detected frogs upstream of the carriageway nor within the revegetated areas bordering the culvert. Frogs do remain on the downstream side where small numbers of sub adults and young adult frogs are regularly captured around a deep pool. The same appears to occur at the nearby reference site off McPhillips Road where frogs tend to concentrate

around one or two pools over the 500 m transect. Surveys along the frog fence extents at Boneys Creek found no Giant Barred Frogs on the road side of the fence and this has remained so over the past three rounds of monitoring.

Based on the Year 5 findings, the following recommendation is outlined in Table 3-4.

Table 3-4. Recommendations following Year 5 Giant barred Frog population monitoring and Transport for NSW response.

Recommendation No	Recommendation	Transport for NSW Response
1.	Undertake a one off targeted survey for Giant Barred Frog at Corindi Creek and Halfway Creek during a flood event to evaluate the risk of installed fencing around stone pitching and bridge abutment areas given frog fencing has not been installed, is the incorrect design or the uneven ground creates a degree of permeability.	Not adopted – TfNSW will perform some on ground works to reduce frogs from entering the carriageway during a flood event when frogs move away from flood water.
2.	Perform another round of monitoring at Corindi Creek, Halfway Creek and Boneys Creek to demonstrate connectivity structures have been effective for three consecutive years.	Corindi Creek – Not adopted – The acceptable measure of success in the TFMP is >1% of the estimated population size or simply based on the total number of frogs captured and marked versus the number recorded as recaptures that have moved across the carriageway.. The data demonstrates this has been successfully achieved and doesn't warrant any further monitoring. Halfway Creek - Not adopted – The acceptable measure of success in the TFMP is >1% of the estimated population size or simply based on the total number of frogs captured and marked versus the number recorded as recaptures that have moved across the carriageway.. The data demonstrates this has been successfully achieved and doesn't warrant any further monitoring. Boneys Creek – Not adopted – To date, no suitable habitat or Giant Barred Frogs have been found upstream of carriageway to warrant additional monitoring. Frog fence surveys have not recorded Giant Barred Frog on the road side of the fence.
3	Cease monitoring at Dirty Creek as three consecutive years of operational monitoring has been performed and no relevant connectivity structures and frog fencing.	Adopted – TfNSW agree the population is functioning in a manner consistent with baseline survey data.
4	Investigate installing a locked gate to reduce public access beneath bridge abutments at Halfway Creek.	Not adopted - this was investigated by TfNSW, however access must be maintained for utility providers.

4.0 WALLUM SEDGE FROG (*LITORIA OLONGBURENSIS*)

4.1 Species Profile

4.1.1 Description

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

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

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

4.1.2 Distribution

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

4.1.3 Habitat and Ecology

The Wallum Sedge Frog is an "acid" frog confined to the coastal sandplain wallum swamps. Their life-cycle is adapted to the acidic pH (2.8-5.5) of these wetlands. Frogs are highest in abundance in relatively undisturbed wallum swamps. Breeding habitat is characterised by the presence of emergent sedges, with upright species such as *Baumea* spp. and *Schoenus* spp. preferred by adult frogs for perching. Frogs can be found in breeding habitat throughout the year although there appears to be some localised movements during or shortly after rainfall (Lewis and Goldingay 2005). Breeding occurs mainly in spring, summer and autumn after rain. Eggs are laid singly in water at the base of sedges (OEH 2014).

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

4.1.4 Conservation Status

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

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

4.2 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.

4.2.1 Site Selection and Treatment Design

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

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

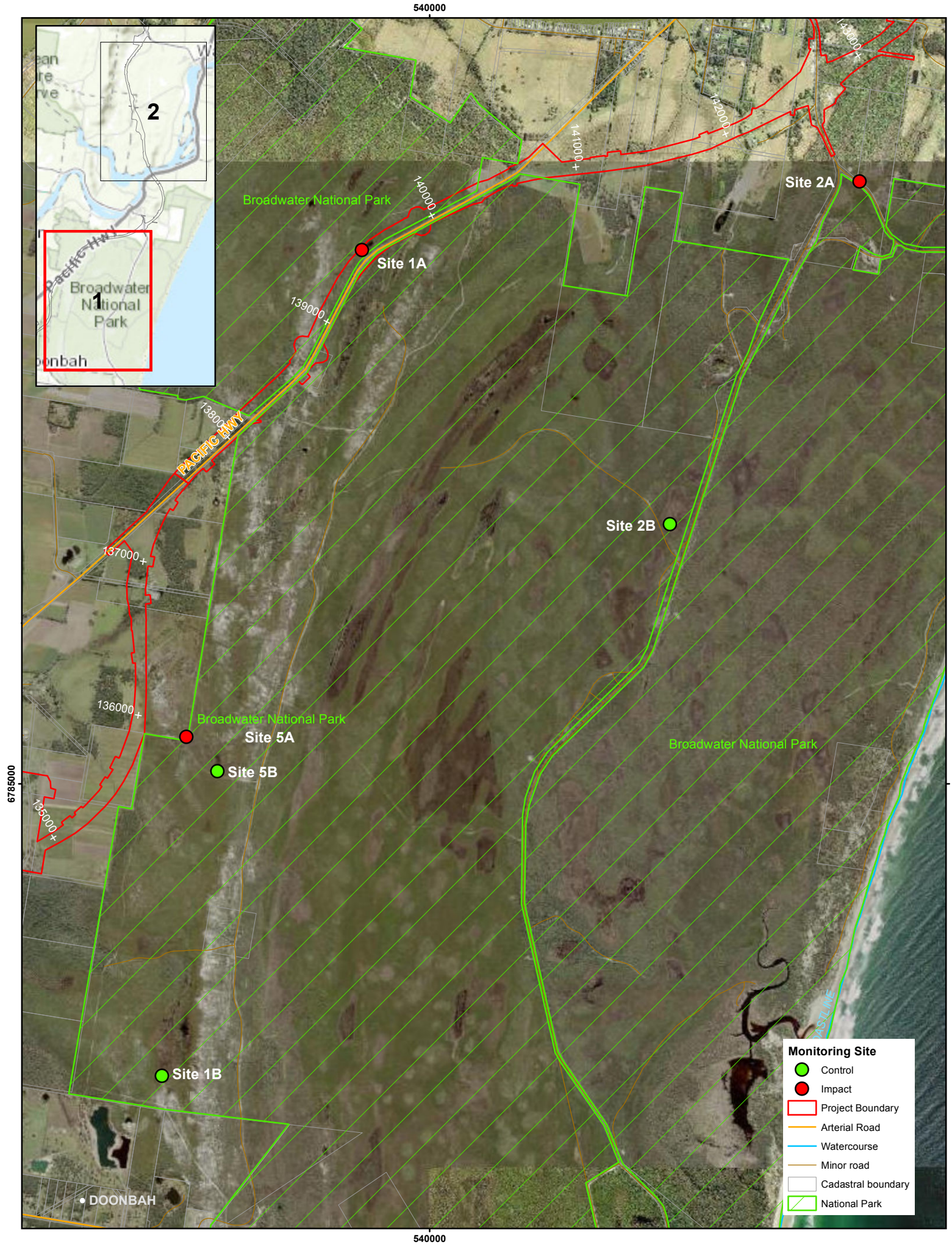
4.2.2 Timing of Surveys

Field surveys were comprised of two sampling periods with each event taking place 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 in early February 2019 and a follow up post breeding survey to determine the level of breeding success was performed at the start of June 2019 (Appendix A). The slight delay in the start of the calling or breeding survey was attributed to ongoing dry conditions where no rainfall was recorded during the month of January 2019 at the Woodburn monitoring station (No. 58061).

4.2.3 Frog Surveys

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

- Surveys were performed generally within 7 days of a notable rainfall event (>10 mm in 24 hrs) using the Bureau of Meteorology (BoM) weather stations at Evans Head (058212) or Woodburn (58061; *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 as other sites where a 50 m transect could not be installed dur 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.



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File:	3031718i-FIG-1-1-WALLUM-SEDGE-MONITORING-150527

N W E S

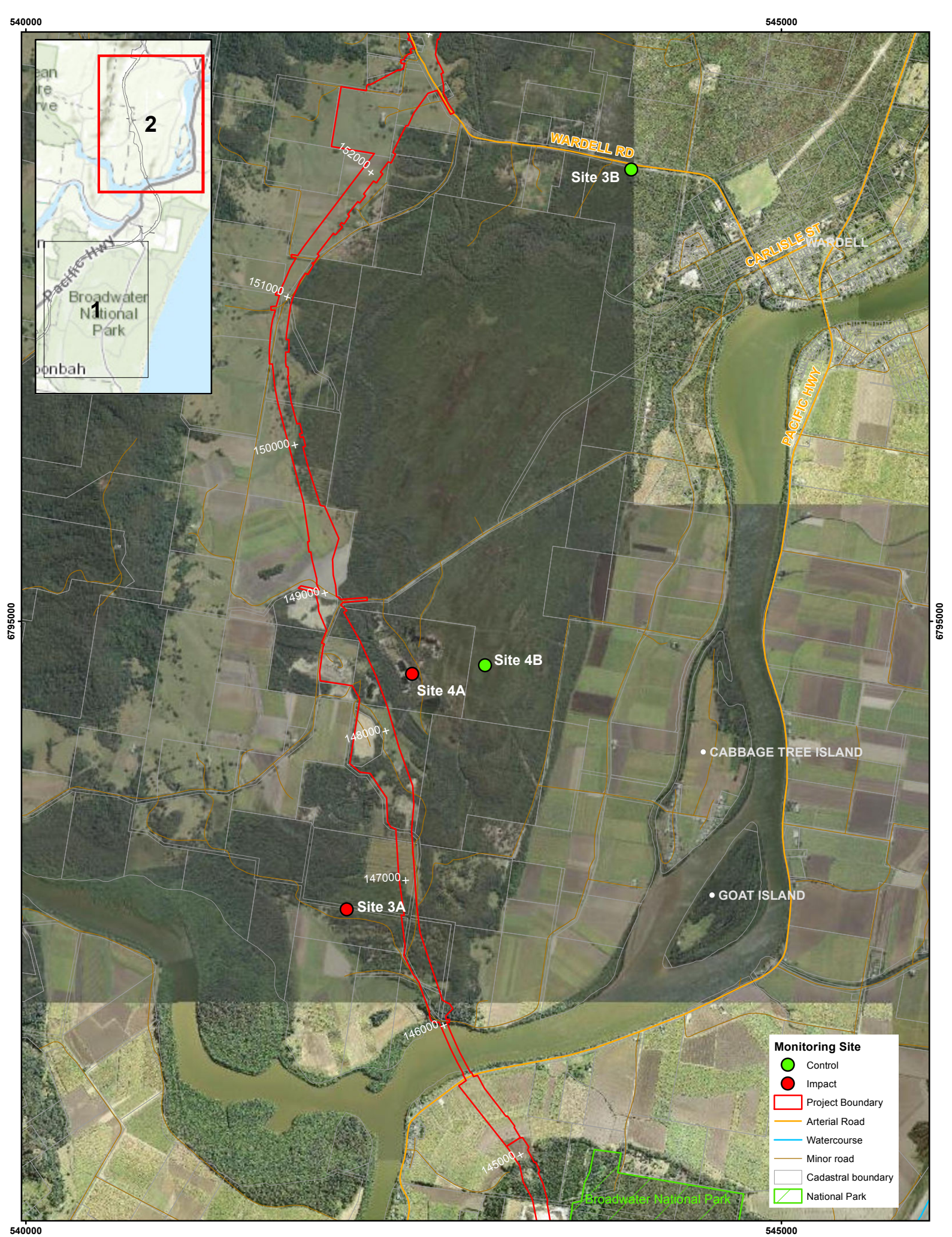
0 250 500 750 1,000
Meters

A4 Scale 1:30,000

Coordinate System: MGA56 Projection: Transverse Mercator

Figure 4-1:

WALLUM SEDGE FROG YEAR 3 MONITORING



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0 250 500 750 1,000
Meters

A4 Scale 1:30,000

Coordinate System: MGA56 Projection: Transverse Mercator

Figure 4-2:

WALLUM SEDGE FROG YEAR 3 MONITORING

4.2.4 Abiotic Data

The following abiotic variables were collected during the survey:

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

4.2.5 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 not fully complete with regards to landscaping treatment, fencing and soft passage.

4.2.6 Compensatory Breeding Ponds

No locations or status was provided for the proposed compensatory breeding ponds during the Year 3 monitoring program. Consequently, no monitoring was performed.

4.3 Year 3 Construction Monitoring Results

4.3.1 Sedge Frog Abundance

Wallum Sedge Frogs were recorded at 6 (60%) of the 10 monitoring sites during Year 3 (Table 4-1; Figure 4-3). Similar to previous monitoring events, sedge frogs were not recorded from Site 2A (Broadwater Beach Road), 3A (Bagotville), 3B (Wardell Road) and now 5A (McDonalds). The highest counts of sedge frogs were recorded at the control sites located in Broadwater National Park with 21 and 20 frogs per 100m^2 of habitat at Site 2B and 5B respectively (Figure 4-3). Overall, sedge frog numbers were comparable to the previous Year 2 monitoring but remain on average substantially lower than the baseline surveys (Figure 4-3).

Adult frogs were recorded at six sites, however, they were only recorded during the winter survey at Site 4A (Ballina Shire Council Quarry) and 4B (Jali Lands; Figure 4-4) which contained some surface water following autumn rains. Sub adult frogs were also recorded at all six sites, and with this, confirming sedge frogs had successfully breed during the 2018/19 monitoring season. Interestingly, this age class was recorded during both surveys at Site 2B and 5B indicating breeding had occurred on at least two separate occasions, probably December 2018 and in autumn 2019. Juvenile frogs were recorded at four sites (1A, 2B, 4A, 5B) and were only recorded during the winter survey indicating a successful breeding event sometime in early autumn. No tadpoles were recorded during either of the surveys.

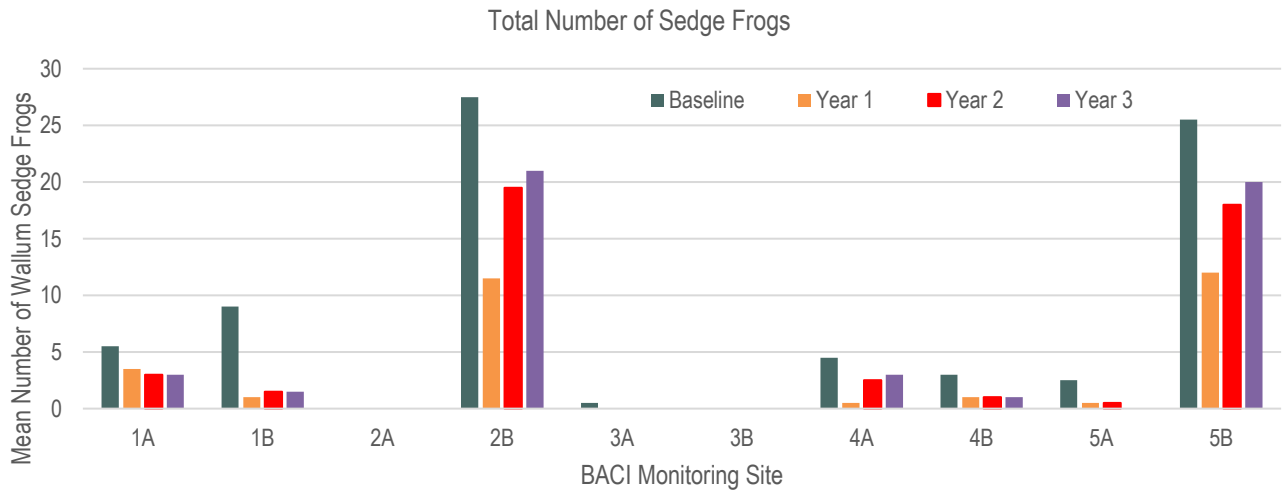


Figure 4-3. Wallum sedge frog counts between baseline survey, Year 1, Year 2 and Year 3 monitoring.

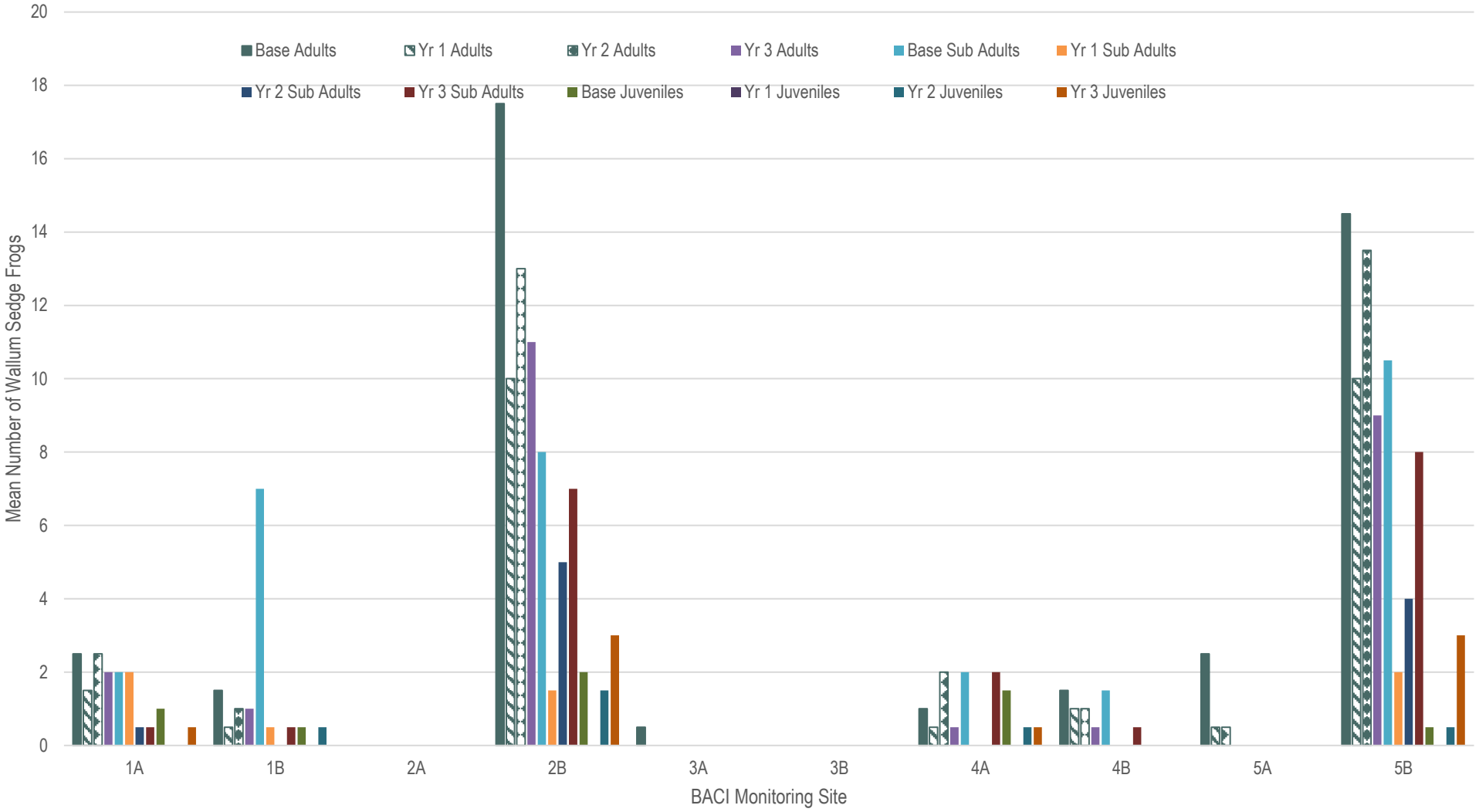


Figure 4-4. Wallum sedge frog counts across three age classes between baseline survey and subsequent monitoring in Year 1, 2 and 3.

Table 4-1. Summary of the sites and mean Wallum Sedge Frog counts between baseline survey and Years 1-3.

BACI Site	Treatment Class	Site Name	Chainage Extent	Base Adults	Yr 1 Adults	Yr 2 Adults	Yr 3 Adults	Base Sub Adults	Yr 1 Sub Adults	Yr 2 Sub Adults	Yr 3 Sub Adults	Base Juveniles	Yr 1 Juveniles	Yr 2 Juveniles	Yr 3 Juveniles
1A	Impact	Broadwater West	139500	2.5	1.5	2.5	2	2	2	0.5	0.5	1	0	0	0.5
1B	Control	Broadwater West	133000–132000	1.5	0.5	1	1	7	0.5	0	0.5	0.5	0	0.5	0
2A	Impact	Broadwater Beach Road	143000–142000	0	0	0	0	0	0	0	0	0	0	0	0
2B	Control	Broadwater East	137000-138000	17.5	10	13	11	8	1.5	5	7	2	0	1.5	3
3A	Impact	Bagotville	146000-147000	0.5	0	0	0	0	0	0	0	0	0	0	0
3B	Control	Wardell Road	151000-152000	0	0	0	0	0	0	0	0	0	0	0	0
4A	Impact	Ballina Shire Council Quarry	148000-149000	1	0.5	2	0.5	2	0	0	2	1.5	0	0.5	0.5
4B	Control	Jali Land	148000-149000	1.5	1	1	0.5	1.5	0	0	0.5	0	0	0	0
5A	Impact	McDonalds	135900	2.5	0.5	0.5	0	0	0	0	0	0	0	0	0
5B	Control	Broadwater National Park	135800	14.5	10	13.5	9	10.5	2	4	8	0.5	0	0.5	3

Yr – Year

4.3.2 Constructed Breeding Ponds

At the time of Year 3 monitoring, no compensatory breeding ponds had been constructed for sedge frogs.

4.3.3 Frog Fencing

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

- 139000 adjacent to the bridge in Broadwater National Park;
- 139400 139600 (200m) which is adjacent to Site 1A; and
- 139900 to 140100 (200 m) which is a few hundred metres to the north of Site 1A where twin 450 mm culverts.

No sedge frogs were recorded on the road side of these fencing extents nor were any recorded close (i.e. < 5m) to the fence on the habitat side. In fact, the only sedge frogs recorded in this area was at Site 1A.

4.4 Discussion

Monitoring during Year 3 found fewer sedge frogs then during the baseline surveys conducted in 2014. This trend of fewer sedge frogs has remained relatively consistent over the past three annual rounds of construction monitoring. The relatively dry summers that have coincided with the first round of monitoring have probably contributed to the low overall counts of sedge frogs. At these times, the monitoring transects often contain little or no surface water, and with that, sedge frogs have either retracted to areas adjacent to the monitoring transect, sought refuge in dense vegetation or beneath bark or remain at lower densities where they continue to forage.

During this round of monitoring, a Cane Toad (*Rhinella marina*) was recorded for the first time at Site 1A with an adult male observed at the dry transect during the summer survey. This site was located in an area of dense dry and wet heath land which has now been cleared to accommodate the north bound carriageway. Toads are known to preferentially use cleared habitats for movement and breeding in north east NSW (e.g. Semeniuk *et al.* 2000). Some attention should be given to toad management at this site.

Although sedge frog numbers have remained at densities lower than the baseline surveys, there is an ongoing documented evidence of breeding at two of the impact sites (1A, 4A) and at four of the reference sites (1B, 2B, 4B and 5B). At four of these sites, both juvenile and sub adult sedge frogs were recorded, indicating sedge frogs had bred during prominent rainfall events, probably in mid December 2018 and early April 2019.

Sedge frogs continue to remain absent from Site 2A (Broadwater Beach Road), an area heavily reliant on higher water tables associated with above average seasonal rainfall. On this occasion, the monitoring transect was dry, and during such conditions, it seldom supports sedge frogs (Lewis and Goldingay 2005). A similar situation exists at Site 3A (Bagotville) where no sedge frogs were recorded along the monitoring transect. Despite Site 3B (Wardell Road) containing some surface water during the winter survey, no sedge frogs were recorded. There were, however, a number

of Eastern Sedge Frog (*Litoria fallax*) and Tylers Tree Frog (*Litoria tyleri*) which have increased markedly since some initial monitoring was performed by the author (BDL) at this site in the late 1990's and early 2000's.

No sedge frogs were recorded on the road side of the surveyed frog fence extents that lie adjacent to Site 1A. Sedge frogs in this area tend to remain within the discreet sedge swamp where Site 1A is located and probably only move on wet nights. Although no sedge frogs were found in close proximity to the culvert and bridge between ch.139000 and 139500 these are likely to play an important role in restoring habitat connectivity with more extensive sedge frog populations found to the east in Broadwater National Park. It is unclear if source populations exist west towards Rileys Hill.

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

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

4.5 Performance Indicators and Corrective Actions

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

Year 3 monitoring includes the population monitoring component as well as some of the connectivity structures, but not the compensatory ponds and revegetation works as they are either not yet complete or do not form 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 has declined in a relative manner across both the impact and control sites. These have been summarised in Table 4-2 and as follows:

- Site 1 – 45% decline at impact treatment and 83% decline at reference site.
- Site 2 – No change from ongoing absence whilst there has been a 24% decline at reference site.
- Site 3 – 100% decline at impact site and no change at the reference site which has remained at zero.
- Site 4 – 33% decline at both treatments.
- Site 5 – 100% decline at impact site and 22% decline at reference site.

Some of these declines can be partly explained by natural variation or fluctuations with the summer surveys coinciding with ongoing dry conditions when all transects had little or no water, and this reduces the overall habitat suitability for sedge frogs (*see* Lewis and Goldingay 2005). At Site 3A and 5A where 100% declined have been recorded, it is quite likely that sedge frogs occur in nearby adjacent areas or simply sought refuge in dense vegetation or under bark making their detection difficult. Nonetheless, the following corrective actions should be considered:

- *Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance.*
- *Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation.*

The locations of compensatory ponds should now be finalised so that is accords with the commitments identified in the TFMP, that being "*where breeding habitat will be directly impacted by the project or changed hydrological patterns have the potential to affect the suitability of breeding habitat areas adjacent to the corridor*". As the monitoring sites occur outside of riparian areas, the riparian habitat revegetation parameters appear irrelevant at this time.

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

Triggers for corrective actions	Corrective actions	Relevance to Year 3 Wallum Sedge Frog Monitoring	Results of Year 3 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Population Monitoring					
The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys. 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: • 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).	Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance. Investigate effectiveness of frog exclusion fencing immediately. Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation. 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.	Relevant	Wallum Sedge Frogs absent from Site 2A, 3A, 3B and 5A. Compared to the baseline survey, Wallum Sedge Frogs At Site 1 – 45% decline at impact treatment and 83% decline at reference site. Site 2 – No change from ongoing absence whilst there has been a 24% decline at reference site. Site 3 – 100% decline at impact site and no change at reference site which has remained at zero. Site 4 – 33% decline at both treatments. Site 5 – 100% decline at impact site and 22% decline at reference site.	First or summer survey has coincided with ongoing dry conditions with little or no surface water at the monitoring transects which reduces overall habitat suitability. Both Site 3A and 5A where frogs have disappeared (i.e. 100%) have been dry at the time of monitoring. Sedge frogs are likely to occur in nearby adjacent areas or sought refugia in dense vegetation or under bark.	The following corrective actions are considered suitable: *Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance.* Relevant at Site 1, 3 and 5 where decline of abundance by >25%. Review found that whilst surveys were performed at the scheduled time of the year and around the time of recent rainfall, the prolonged period of below average rainfall has resulted in each of these pond areas being dry. With this, frogs are likely to have retreated to alternative areas or sought refuge beneath bark or dense vegetation. Monitoring should ideally occur when the sites have surface water in them again before an assessment should be made in regards to population abundance and associated decline. *Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation.* Recommended that Site 1, 3 and 5 be visited once every 4 weeks to assess water depth for 12 weeks.
Underpass Structure Monitoring					

Triggers for corrective actions	Corrective actions	Relevance to Year 3 Wallum Sedge Frog Monitoring	Results of Year 3 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
The use of the structure by less than 1% of the estimated population size. Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.	Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified. Survey habitat adjoining the connectivity structures and undertake Landscape improvement (planting, weed removal) to improve habitat functionality. 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. Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.	Not relevant as sites have not been completed.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Constructed Pond Monitoring					
Absence of threatened frogs and metamorphs at the compensatory ponds after three years since construction.	Investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (i.e. 3 more years of monitoring) Review monitoring methods, considering timing and weather conditions to ensure individuals are identified. Review location of the compensatory pond and consider moving, and/or modifying or constructing additional ponds. Investigate habitat adjoining the upgraded highway and consider improving habitat condition and connectivity.	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.
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.

Triggers for corrective actions	Corrective actions	Relevance to Year 3 Wallum Sedge Frog Monitoring	Results of Year 3 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
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 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.	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 suitable for frogs, but not colonised).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	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.
Riparian Habitat Revegetation					
Greater than 10% of riparian plants have died after first 12 months of maintenance. Greater than 20% of riparian plants have died after three years of maintenance.	Review maintenance schedule for revegetated areas immediately after trigger. Replace dead plants within one month of issue being identified. Increase weed control if required as soon as practicable or review control methods being used.	Not applicable as site not in riparian habitat.	Not Applicable	Not Applicable	Not Applicable

Triggers for corrective actions	Corrective actions	Relevance to Year 3 Wallum Sedge Frog Monitoring	Results of Year 3 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Total weed coverage is more than 30% in revegetation areas. Bank erosion causes unforeseen revegetation area instability.	Install physical measures to halt bank erosion within one month of issue being identified.				

4.6 Conclusions and Recommendations

Year 3 monitoring during the summer and early winter of 2019 found sedge frogs at six of the 10 monitoring sites. The continued absence from Site 2A (Broadwater Beach Road), both of the Site 3 treatments (Bogotville and Wardell Road) and 5A (McDonalds) reflects small populations that rely on source populations from nearby locations and are reliant on higher ground water tables than what has been experienced during the past few years of monitoring.

Year 3 provided the first opportunity to assess the performance of the monitoring program in accordance with the TFMP (RMS 2015). Sedge frog numbers were found to have declined at rates of 22-100% across all of the monitoring sites, regardless of the treatment type. Where there has been no change, such as Site 2A (Broadwater Beach Road) and 3B (Wardell Road), this simply relates to the baseline survey recorded no sedge frogs despite the author having previously recorded sedge frogs at these locations previously. Whilst declines have exceeded the thresholds outlined in the TFMP at Site 1 (Broadwater West), Site 3 (Bogotville) and Site 5 (McDonalds), both of these sites are heavily reliant on adjacent source populations and higher ground water tables from average to above average rainfall events. Some strategic surveying immediately after some substantive rainfall (>40 mm in 24 hrs) would assist in interpreting the status of sedge frog densities at these two sites.

No compensatory ponds have been constructed to date. Consideration should be given to establishing ponds early during the construction phase so that the difficulties can be more readily addressed ahead of the operation phase. Some settling time is required and this will take additional time should the process occur during an extended period of below average rainfall.

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

Table 4-3. Recommendations following Year 3 Wallum Sedge Frog population monitoring and Transport for NSW response.

Recommendation No	Recommendation	Transport for NSW Response
1.	Address corrective actions for Site 1, 3 and 5: a. *Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance.* Review found that whilst surveys were performed at the scheduled time of the year and around the time of recent rainfall, the prolonged period of below average rainfall has resulted in each of these pond areas being dry. With this, frogs are likely to have retreated to alternative areas or sought refuge beneath bark or dense vegetation. Monitoring should ideally occur when the sites have surface water in them again before an assessment should be made in regards to population abundance and associated decline. b. *Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation.* Recommended that Site 1, 3 and 5 be visited once every 4 weeks to assess water depth for 12 weeks.	a. Adopted – TfNSW agree that surveys should ideally be guided by the ecologist but would appreciate some progress report should dry conditions extend past February 2021. b. Not adopted – TfNSW support the flexibility in survey times provided above which should eliminate the need to closely monitor habitat conditions at Site 1, 3 and 5.
2	Ensure construction of the compensatory breeding ponds commence early in the construction program in accordance with the Threatened Frog Management Plan which states this will be "*finalised during the detailed design of these areas of the project*"	Please note that no ponds are proposed for WSF. Sites were considered and advice received from author of this report which was provided to EPA on 27/8/20. It was determined that constructing ponds at these locations may impact on existent WSF habitat and potential to change existing drainage within the habitat.
3	Implement toad management measures for Site 1A.	Not adopted - Toads have been identified in numerous locations north of the Clarence, however, our advice from toad control contractor is to focus efforts around the current biosecurity control line.
4	Ensure vegetation is trimmed or removed from frog fence extents so that the fence remains effective.  **Plate 4-3**. Example of vegetation growing up, through and over the frog fence adjacent Site 1A.	Noted - Vegetation maintenance along fauna fencing will be undertaken as part of the fauna fencing maintenance program.

5.0 GREEN-THIGHED FROG (*LITORIA BREVIPALMATA*)

5.1 Species Profile

5.1.1 Description

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

Plate 5-1. Green-thighed Frog.

5.1.2 Distribution

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

5.1.3 Habitat and Ecology

The cryptic habits of the Green-thighed Frog ensured it remained unknown to science until 1972 (Tyler *et al.* 1972). The main habitat requirement of this species is warm temperate lowland forest, although more recent records have indicated other habitat types including dry sclerophyll forest, heathland and swamp forest are used (Nattrass and Ingram 1993; Lemckert 1999; Murphy and Turnbill 1999; Lewis 2000; Lewis 2006). The Green-thighed Frog is most often detected during breeding events between October and April when males congregate around flooded depressions and call from either the ground or low fallen branches or vegetation (Barker *et al.* 1995; Ehmann 1997; Lemckert *et al.* 2006). Typically, calling events occur when the breeding site has received at least 75 mm in 24 hours or around 150 mm over a 72 hour period (B. Lewis unpublished data).

5.2 Survey Methods

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

5.2.1 Site Selection

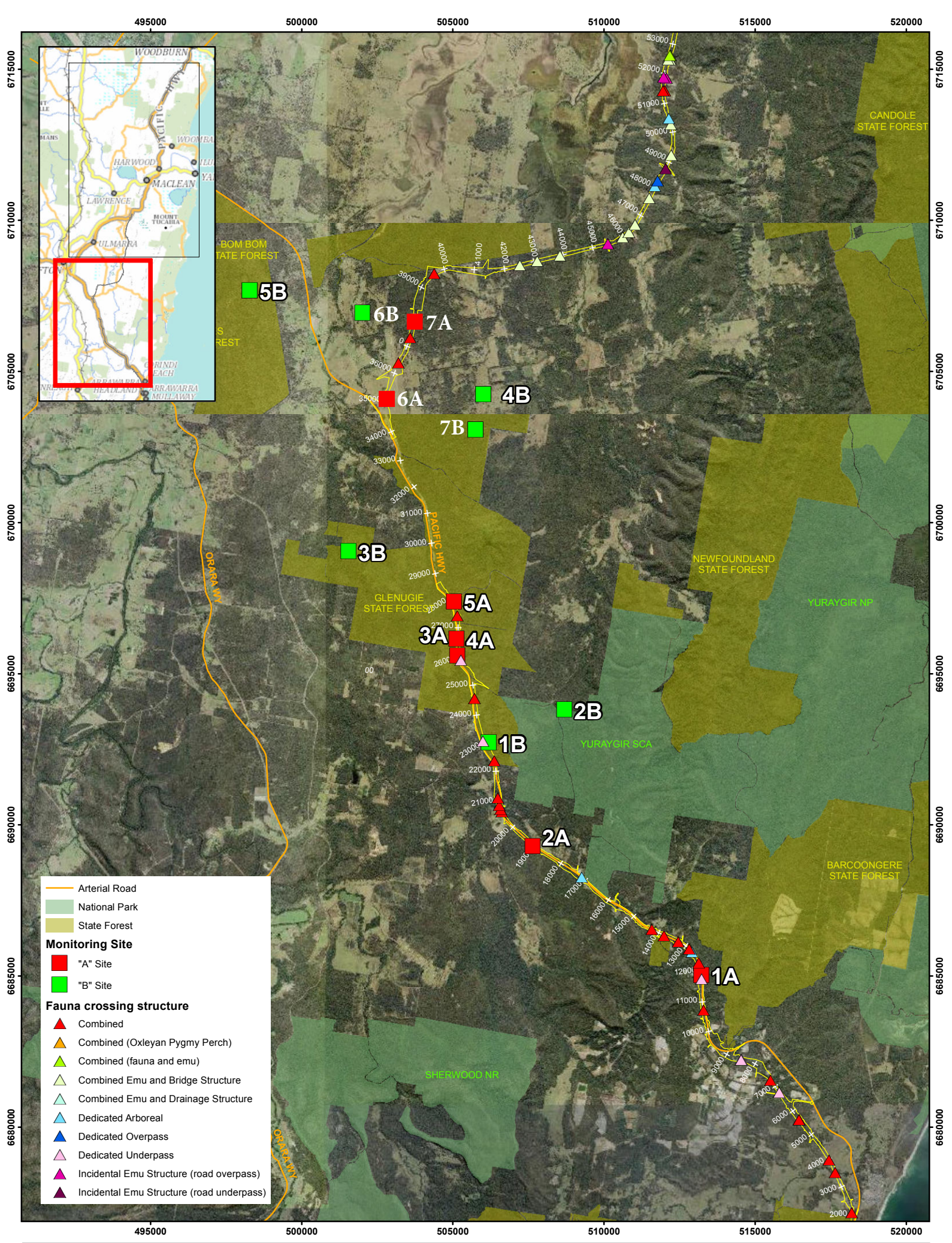
The location of BACI sites 1-5 are located in Section 1 and 2 whilst sites 6 to 10 are located in Section 3-7 and were selected during follow up surveys and updating of baseline information in 2015 (Lewis 2015; Figure 5-1).

5.2.2 Timing of Surveys

Weather patterns were constantly monitored between October 2019 through to May 2020 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 17-19th of January 2020 for Sites 1-10 whilst some additional surveys were performed around the 9th February 2020 at Site 6 and 7 in Section 3.

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.

The second round or post breeding surveys were used to measure the breeding success at each site and these were performed on the 26th February to 1st March 2020 for Sites 1 to 5 and 8-10, or around 40 days after the potential breeding event. Another survey was performed on the 22nd March 2020 at Site 6A and 7A in Section 3 around 42 days after the potential breeding event in early February. 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 25m^2 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.



LEWIS ECOLOGICAL

Source:	Aerial Photo: © Land and Property Information 2015 Green-thighed Frog Pre-construction Baseline Monitoring: Lewis Ecological 2015 Project Boundary & Chainages: RMS 2013 National Parks: NSW NPWS 2011 State Forests: Forestry Cooperation 2006
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File:	2681617-FIG-1-1-GTF-BASELINE-MONITORING-160810

N W E S

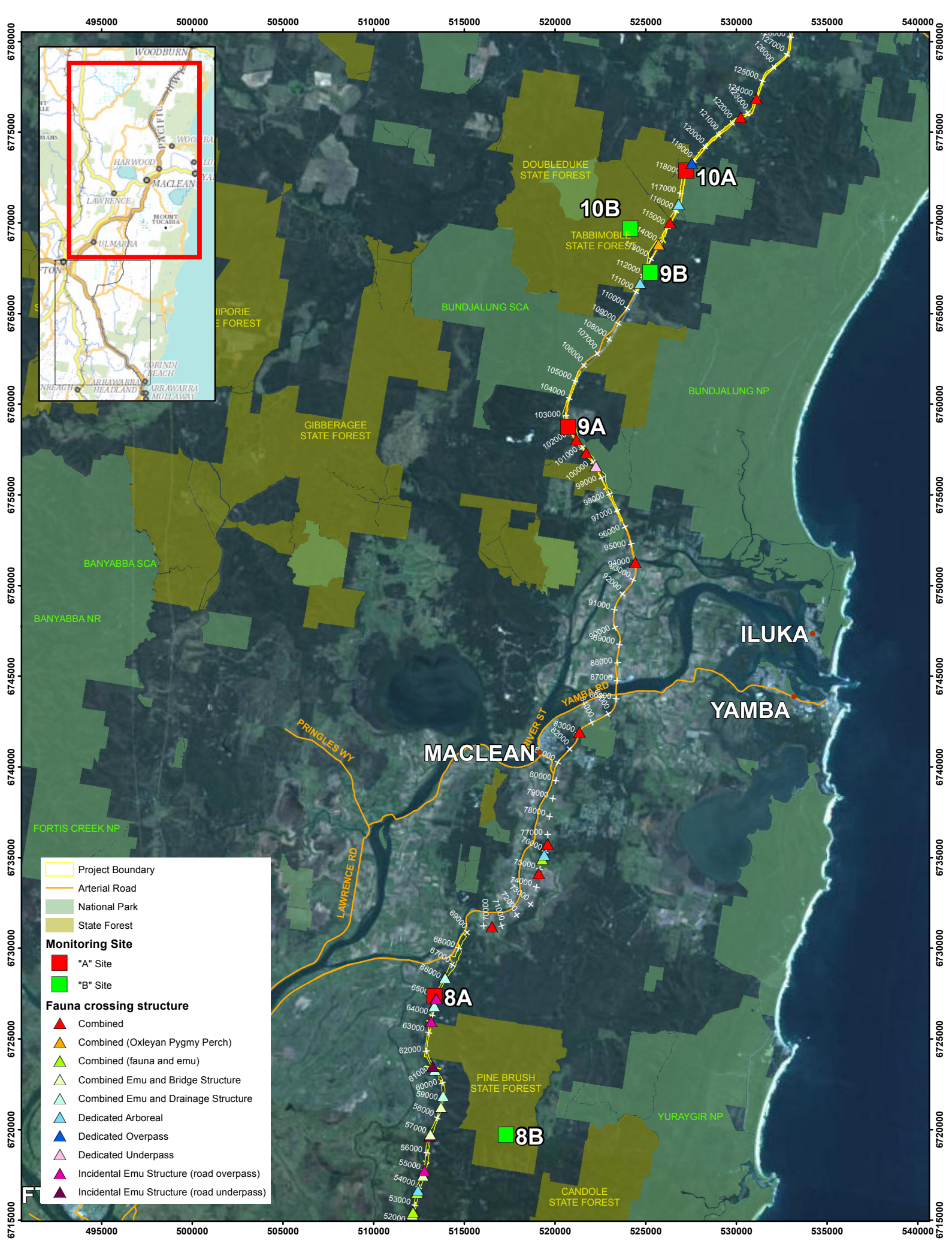
0 1 2 3 4 Kilometers

A4 Scale 1:150,000

Coordinate System: MGA56 Projection: Transverse Mercator

Figure 5-1: Sheet 1 of 2

GREEN-THIGHED FROG MONITORING SITES



LEWIS ECOLOGICAL

Source:	Aerial Photo: © Land and Property Information 2015 Green-thighed Frog Pre-construction Baseline Monitoring: Lewis Ecological 2015 Project Boundary & Chainages: RMS 2013 National Parks: NSW NPWS 2011 State Forests: Forestry Cooporation 2006
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A4 Scale 1:250,000

Coordinate System: MGA56 Projection: Transverse Mercator

Figure 5-2: Sheet 2 of 2

GREEN-THIGHED FROG MONITORING SITES

5.2.3 Abiotic Data

The following abiotic variables were collected during the survey:

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

5.2.4 Connectivity Structure Monitoring

Ten connectivity structures have been nominated for Green-thighed Frog monitoring and extend from ch. 19180 (BACI Site 2A) to 118464 (BACI Site 10A). Only one of the six southern structures (ch.19180) was surveyed on the 19th January whilst the other five remained under construction. The four remaining northern structures (ch. 102670-118464) were also under construction and were not surveyed. At ch. 19180, a 20-25 min search was used to detect frogs within 100 m of the connectivity structure (Plate 5-1). 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.

Plate 5-2. Sampling of the structure at ch.19180 on the 19th January 2020.

5.3 Monitoring Results

5.3.1 Stage 1 Surveys - Calling Intensity and Spotlighting

Green-thighed Frogs were recorded at 15 (75%) of the 20 sites as part of Year 5 monitoring in Sections 1 and 2 and Year 4 in Sections 3-7 (Table 3-1; Figure 3-1). Frogs were recorded from six (60%) of the impact sites and from nine (90%) of the control sites. Counts and chorusing male frogs regularly exceeded 10 individuals with some of the most notable finds including:

- 25 calling males from Site 9A (Jackybulbin) with 26 frogs observed including a number of amplecting pairs with this site having been burnt in November 2019 wild fires just 2 months earlier (Plate 5-2);
- Site 4B and 7B in Glenugie State Forest with counts of 24 and 14 frogs along with many males calling at each site, and
- Site 6A with 11 calling males at sporadic locations with 15 individuals observed including both males and females but no amplecting pairs.

Frogs numbers remained low in Section 1 with no frogs recorded from Site 1A (Falconers) nor Site 2A (Halfway Creek). Amplecting or mating frogs were recorded from Site 3A (Bald Knob Tick Gate Road), 5B (Bom State Forest), 6B (Airport Road), 7B (Glenugie State Forest east), 9A (Jackybulbin) and 9B (Tabbimoble east).

Plate 5-3. Green-thighed Frogs (male left – female right) recorded from Site 9A (ch.102500) in January 2020 following wildfires that burnt much of the area.

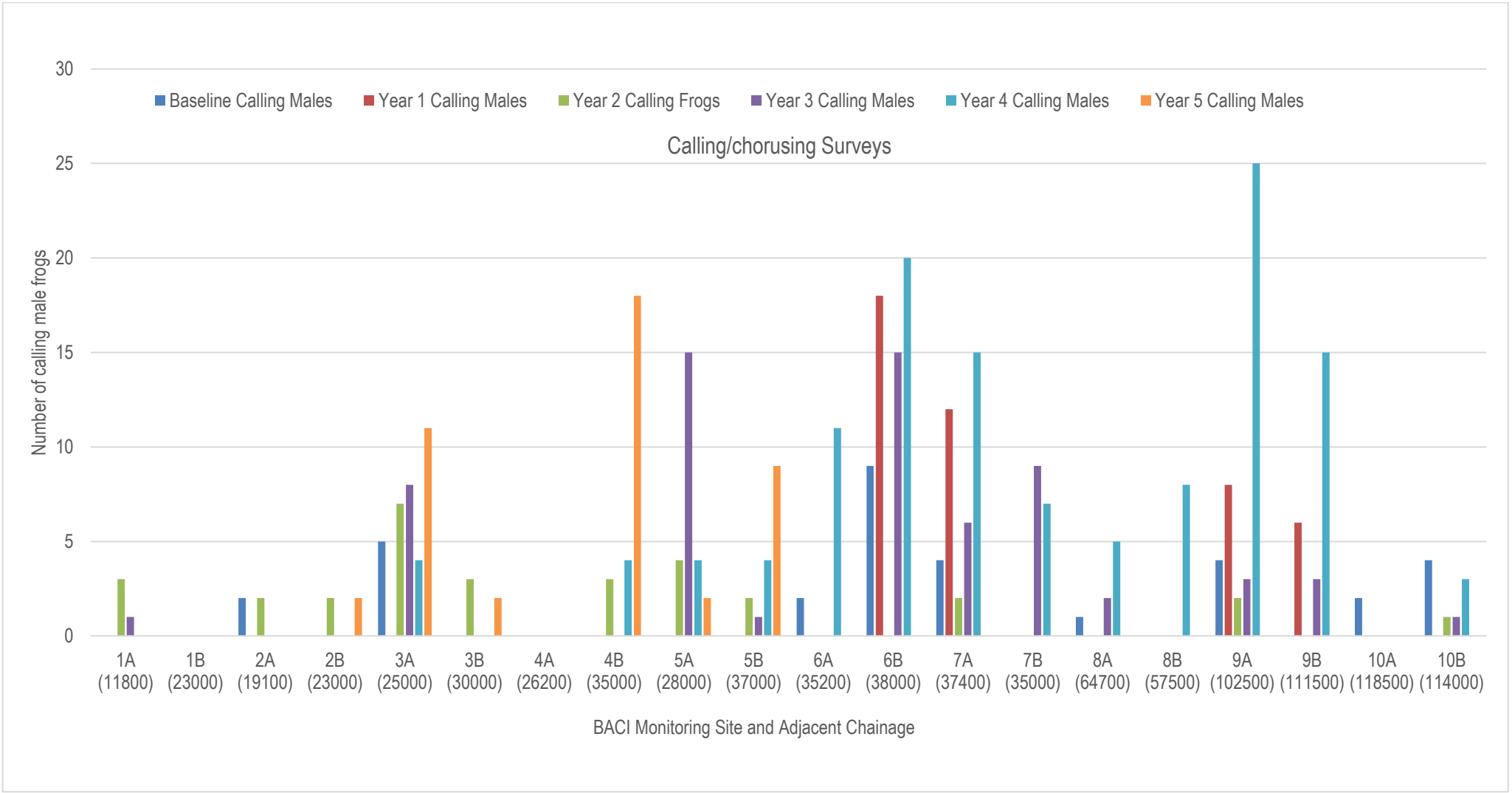

Figure 5-3. The number of calling male Green-thighed Frogs between the baseline survey, construction and operational monitoring in Years 1, 2, 3, 4 and 5 monitoring in Years 1-5 at Sites 1-5 and Years1-4 at Sites 6-10.

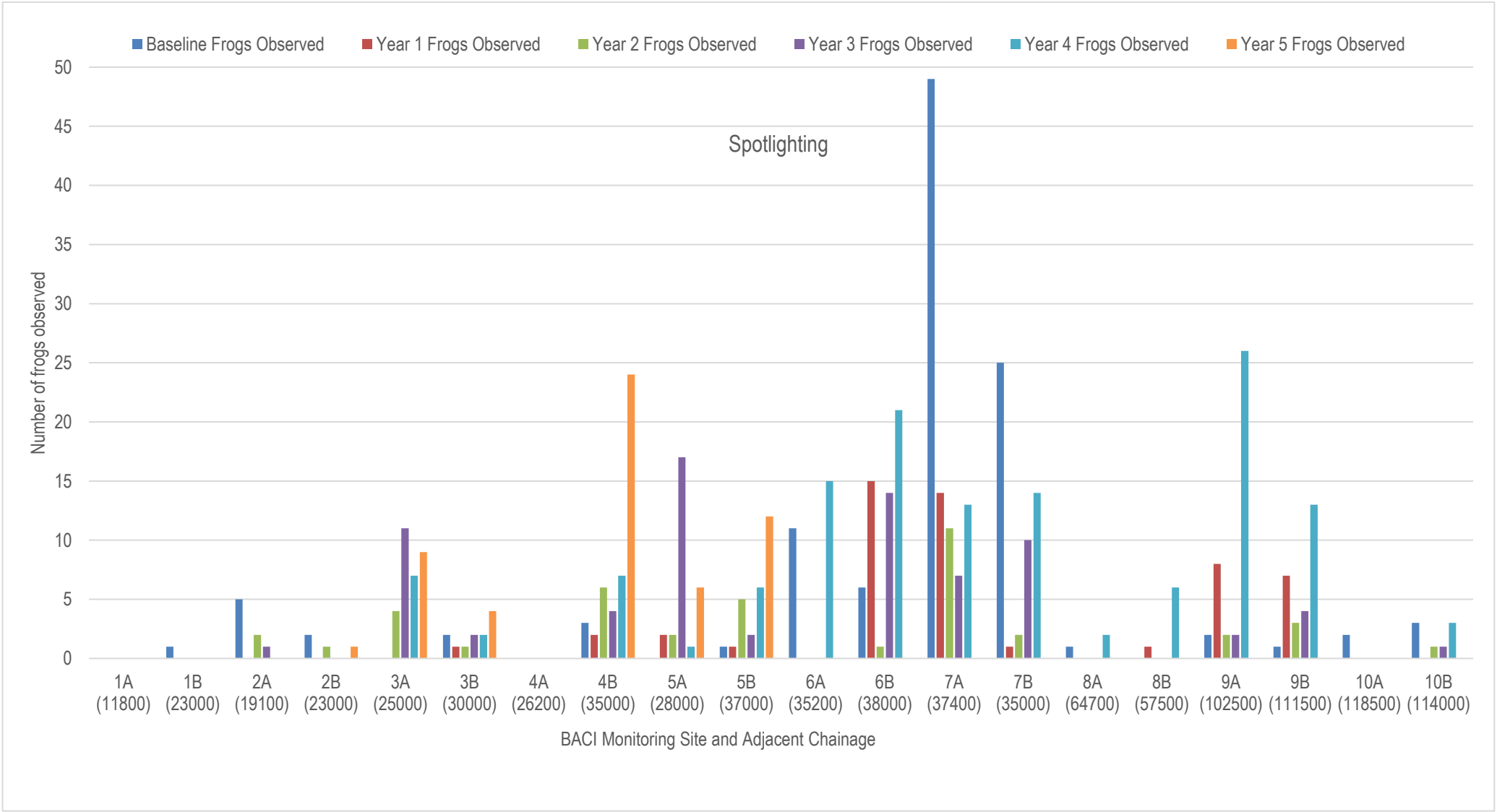

Figure 5-4. The number of Green-thighed Frogs spotlighted between the baseline survey, construction and operational monitoring in Years 1, 2, 3, 4 and 5 monitoring in Years 1-5 at Sites 1-5 and Years1-4 at Sites 6-10.

Table 5-1. Summary of the 2019/2020 Green-thighed Frog surveys for BACI Sites 1-10.

	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey						
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads	Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
1A ch.11800	07.02.2020	0	0	22.03.2020	0	0	0	i. Permanent frog fencing installed adjacent to the compensatory breeding ponds. ii. Compensatory ponds constructed on western side. iii. New ponds have been desilted and reconstructed.	Frogs are likely to opportunistically breed through the broader area so reliable and repeated sampling likely to remain difficult. Newly constructed ponds may increase site suitability.	No
1B ch.23000	07.02.2020	0	0	22.03.2020	0	0	0	i. Site is impacted by works and not considered a control site.	Site back under construction.	No
2A ch.19100	20.01.2020	0	0	29.02.2020	0	0	0	i. Permanent frog fencing observed on both sides of the carriageway in both Giant Barred Frog and Green-thighed Frog configurations. ii. Compensatory ponds constructed on western side towards southern extent of frog exclusion fencing. iii. Culvert underpass provides some habitat connectivity but flooded when breeding events occur and these frogs don't swim too much.	Area appears to dry more rapidly. Adjacent table drains probably increased drainage in this area. The compensatory breeding ponds held water longer during this round of monitoring but only due to extended and heavy periods of rainfall.	Yes
2B ch.23000	20.01.2020	2	1	29.02.2020	0	2	0	Outside works footprint.	Site was used for first time in a number of seasons.	Yes
3A ch.25000 (new)	21.01.2020	11	9	29.02.2020	0	7	2	i. Newly constructed compensatory breeding ponds installed in late winter 2018. ii. Permanent frog fencing observed.	Two males recorded calling from constructed ponds and female ~2m away on leaf litter. In general, frogs tend to favour old borrow pit adjacent to constructed breeding ponds. Adjacent north bound carriageway under construction.	Yes

	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey						
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads	Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
								iii. RCP culvert located 250 m to the south as a form of habitat connectivity. iii. Site back under construction.		
3B ch.30000	21.01.2020	2	4	29.02.2020	0	0	0	Outside works footprint.	Difficult site to pin point breeding areas and likely to vary based on extent of seasonal heavy rains, depressions left from upturned trees and localised earthworks and associated drainage.	Yes
4A ch.26200	20.01.2020	0	0	29.02.2020	0	0	0	i. Permanent frog fencing now dismantled and removed.	Area back under construction with frog fence removed as well some of the frog habitat areas.	No
4B ch.35000	20.01.2020	18	24	29.02.2020	0	15	2	Outside works footprint.	Frogs are generally scattered throughout this section of Glenugie State Forest. High frog counts influenced by heavy rainfall which has been greater than previous monitoring events in mid summer.	Yes
5A ch.28000	20.01.2020	2	6	29.02.2020	0	7	3	i. Permanent frog fence installed. ii. No compensatory ponds installed due to natural depressions that provide the same function and are currently used by frogs.	Frogs selected more natural ponds on this occasion where successful breeding was recorded. Success was heavily influenced by follow up rain in February or around 3 weeks after initial breeding event.	Yes
6A (35200)	20.01.2020	9	12	29.02.2020	0	3	0	i. Permanent frog fence installed. ii. No compensatory ponds installed iii. Combined culvert installed.	Main breeding area removed by carriageway. No constructed breeding ponds.	Yes
6B (38000)	08.02.2020	11	15	22.03.2020	0	2	0	Outside works footprint but close to Airport Road.	High frog counts influenced by heavy rainfall which has been greater than previous monitoring events in mid summer.	Yes
7A (37400)	19.01.2020	20	21	29.02.2020	0	17	2	i. Permanent frog fencing installed. iii. Combined culvert installed in general area.	No constructed breeding ponds. Compensatory ponds recommended at this site. Insufficient follow up rainfall contributed to reduced breeding success.	Yes

	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey						
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads	Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
7B (35000)	08.02.2020	15	13	22.03.2020	0	3	0	Outside works footprint.	Frogs are generally scattered throughout this section of Glenugie State Forest. High frog counts influenced by heavy rainfall which has been greater than previous monitoring events in mid summer.	No
8A (64700)	20.01.2020	7	14	29.02.2020	0	5	0	i. Permanent frog fence installed. ii. Access road graded which has reduced its suitability for Green-thighed Frogs based on past observations.	Frog fence appears to function in an effective manner. Frogs heard calling from adjacent private property during this monitoring period. Makes follow up surveys to confirm breeding success difficult as adjacent ponds form focus of sampling.	No
8B (57500)	20.01.2020	5	2	28.02.2020	0	0	0	Outside works footprint.	Frogs appear to vary their breeding site and with drier seasons, the calling/breeding site now appears to occur in the drainage line around 300 m to north.	No
9A (102500)	20.01.2020	8	6	28.02.2020	0	0	0	i. Permanent frog exclusion fencing observed. ii. The installed RCP culverts provide marginal opportunity at improving habitat connectivity.	High frog counts influenced by heavy rainfall which has been greater than previous monitoring events in mid summer. Entire area was burnt during the November 2019 fires	No
9B (111500)	19.01.2020	25	26	28.02.2020	0	11	0	Outside works footprint.	High frog counts influenced by heavy rainfall which has been greater than previous monitoring events in mid summer. Entire area was burnt during the November 2019 fires	No
10A (118500)	19.01.2020	15	13	28.02.2020	0	5	2	i. Permanent frog fence installed on the western side where the monitoring site was previously located. ii. Bridge structure was partly completed.	Old breeding pond has been removed to accommodate the north bound carriageway. The survey now focuses in and around the drainage line to the west. Numerous Cane Toad observed around drainage line.	Yes

	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey						
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads	Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
10B (114000)	19.01.2020	0	0	28.02.2020	0	0	0	Outside works footprint	Calling or breeding location varies markedly within this area and tends to be influences by the extent of road maintenance works and the amount of prevailing rainfall. Area was entirely burnt in Nov 2019 fires.	No

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

Both tadpoles and juvenile frogs were recorded during this round of monitoring (Table 5-1). Tadpoles were recorded at five sites; Site 3A (Bald Knob Tick gate Road), 4B (Glenugie East), 5A (Franklins Road), 6B (Airport Road) and 9A (Jackybulbin) whilst juvenile frogs were recorded at 11 sites including six reference sites and five impact sites. The breeding sites benefited from follow up rain and whilst some ponds dried between these events, many retained water over a number of months (Appendix A-2).

5.3.3 Seasonal Rainfall and Associated Survey Conditions

Suitable seasonal conditions in the form of heavy rainfall events exceeding 50 mm in 24 hours or cumulative tallies exceeding 150 mm in 72 hours occurred on multiple occasions in January and February during this round of monitoring (Table A-2). Rainfall events exceeding 50 mm in 24 hours occurred on the 18th and 19th January 2020 (155mm and 117 mm) and this was followed up with rainfall events on 7th, 9th and 13th February (106mm, 102mm, 93 mm). At Sites 9 and 10, multiple events were recorded on the 18th and 19th January 2020 (102mm, 64 mm) and again on the 7th, 9th and 13th February (140mm, 115mm, 100 mm).

5.3.4 Constructed Breeding Ponds

No Green-thighed Frogs were recorded breeding in the constructed ponds at Redbank Creek (ch. 5600 E) nor at Site 1A (ch.11800 W) and Site 2A (ch. 19100 W). Two calling males and a nearby female frog were recorded from Site 3A (ch. 25000). A summary of the site inspections is presented below and summarised in Table 5-2.

i. Redbank Creek Ponds (5600 E)

Monitoring commenced on the 19th January 2020 following a rainfall event of approximately 300 mm over the 17th to 19th January leaving all four ponds filled to capacity. At this time, no Green-thighed Frogs were heard or observed around the ponds although a number of males were heard calling from the western side of the carriageway and also further to the north to the east of the McLaughlin Road overbridge.

A follow up survey 21 days later on the 8th February found these ponds were still or close to 100% capacity following heavy rainfall of approximately 140 mm in the 72 hrs before the inspection. Additional surveys on the 29th February found all four ponds still contained water, albeit at varying levels from 30% to 80% capacity. During these surveys, at least 20 juvenile Broad-palmed Frog (*Litoria latopalmata*) were recorded around the *Juncus* sedges growing at the edge of these ponds along with some other hylids, most notably Bleating Tree Frog (*Litoria dentata*). No Green-thighed Frog metamorphs, juveniles or tadpoles were recorded. The most important finding is the fact the ponds are drying at differing rates, so they continue to conform to the design intensions of the Threatened Frog Management Plan (RMS 2015).

ii. Falconers (11800 W)

Monitoring commenced on the evening of the 7th February 2020 where all five ponds had filled and over flowed following an estimated 100 mm rainfall event leading up to the survey. No Green-thighed Frogs were heard calling from around the ponds.

A follow up survey on the 29th February showed all five ponds contained water with capacity measured at 40-60% and they were likely to have contained water throughout the past 22 days. A follow up survey on the 22nd March or around 44 days after the initial site survey found one pond had dried out whilst the remaining four ponds contained between 10-40% of their capacity. Only Broad-palmed Frog metamorphs, tadpoles and at least around 10 metamorphs were found whilst some other frogs were present, namely Common Eastern Froglet (*Crinia signifera*). Whilst some ponds still show some siltation, the ponds dried at differing rates and with that, they meet the design intensions of the Threatened Frog Management Plan.

Plate 5-4. Pond inspection in late March 2020 showing ponds with (left) and without (right) water at Falconers ch. 11800.

iii. Halfway Creek (19100 W)

Monitoring commenced on the evening of the 20th January 2020 where all three ponds had filled and over flowed following an estimated 300 mm rainfall event. No Green-thighed Frogs were heard calling or observed around the ponds, although large numbers of common frog fauna were present (i.e. Ornate Burrowing Frog, Scarlet-sided Pobblebonk, Bleating Tree Frog, Rocket Frog).

A follow up survey on the 8th February, coincided with another substantial rainfall event well in excess of 100 mm and the ponds were again full or overflowing. Another survey 21 days later on the 29th February found one pond to contain 20% capacity whilst the remaining two ponds were virtually dry (Plate 5-5). The ponds on this occasion were suspected to have contained surface water for at least 30 days and this was due in large to substantive follow up rainfall events at 2-3 week intervals.

Some management intervention is required at this site as has been recommended previous monitoring rounds.

Plate 5-5. One of two main ponds at Halfway Creek in late February with 20% water capacity.

iv. Bald Knob Tick Gate Road (25000 E)

Monitoring commenced on the evening of the 21st January 2020 where all five ponds had filled to capacity following an estimated 300 mm of rainfall in the past 48 hrs (Plate 5-6). At this time, Green-thighed Frogs were heard and observed around one of the constructed ponds whilst a female was observed around 1-2 m away. Most of the calling activity was concentrated at an old borrow pit around 30 m to the west of these newly constructed ponds.

A follow up survey 16 days later on the 7th February found all ponds had remained at capacity or in reality had probably filled with the heavy rainfall the site had received on that day. The following pond survey coincided with stage 2 post breeding surveys on the 29th February 2020. At this time, one pond had almost dried whilst the four remaining ponds contained between 10-40% of their capacity. Surveys found metamorphs identified as Broad-palmed Frog and Bleating Tree Frog, but no Green-thighed Frog.

Little vegetation still exists around three of the five ponds, however, the ponds dry out at differing rates and this meets the design intend outlined in the Threatened Frog Management Plan.

Plate 5-6. Pond inspection in mid January 2020 showing ponds at capacity following heavy rainfall.

v. Compensatory Ponds in Sections 3-7

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

Table 5-2. Summary of compensatory frog pond monitoring during Year 5 in Section 1 and 2 and Year 4 in Section 3, 6 and 7.

Site	Ch. + Side of Carriageway	Number of Constructed Ponds	First Survey	Second Survey	Third Survey	Comments
Redbank Creek	5600 East	4	19 January 2020 All ponds filled to capacity. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	8th February 2020 All ponds filled. Recent 140 mm plus rainfall. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	29th February 2020 Ponds receded to between 30-80% capacity but held water for entire duration of 40 days. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	Ponds worked well given the follow up rain and do appear to dry at different times. Frogs from several hundred metres to north at McLaughlin Road overpass.
Falconers	11800 West	5	7th February 2020 All ponds filled to capacity. All five ponds filled to a depth of 200-300 mm. Visual Water Quality – Turbid from steep batter run off but likely to settle once rain ceases.	29th February 2020 Ponds 40-60%. Likely to have contained water for past 22 days. Visual Water Quality – Similar to surrounding area. Visibility 100 mm or bottom.	22nd March 2020 One pond dry whilst remainder contained 10-40% capacity. Visual Water Quality – Similar to surrounding area. Visibility 100 mm or bottom.	Newly constructed ponds functioning in a manner more consistent with the Threatened Frog Management Plan – adequate size, not filling as quickly with sediment and drying out at increased and varying rates. Follow up rainfall still considered essential for ponds to retain water for more than 30 consecutive days.
Halfway Creek	19100 West	3	20th January 2020 All ponds filled to capacity. Contain 200-350 mm of water. Visual Water Quality – same as adjacent flooded areas to the south with a slight tannin stain.	8th February 2020 All ponds still at capacity. Linked to 100 mm + rainfall. Contain 200-350 mm of water. Visual Water Quality – same as adjacent flooded areas to the south with a slight tannin stain.	29th February 2020 Ponds dry and one at 20% capacity. Visual Water Quality – Either clear or dry.	Heavy follow up rainfall of >50-75 mm appears required every 15-20 days for ponds to retain water over an extended period of 30-40 days. Ponds drying out too quickly and require intervention to retard draining.
Bald Knob Tick Gate Road	25000 East	5	21st January 2020 All ponds filled to capacity. Contain 250-350 mm of water. Visual Water Quality – same as adjacent flooded areas – turbid from surrounding sodic soils.	7th February 2020 All ponds filled to capacity following heavy overnight rainfall. 250-350 mm of water. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	29th February 2020 Ponds 10-40% capacity. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles giving recorded at neighbouring borrow pit.	Second year of monitoring. Two males recorded calling and a female 1-2 m away. Most of the frogs selected a disused borrow pit 30 m away for successful breeding on this occasion. Different drying times is consistent with the design intentions outlined in the Threatened Frog Management Plan.
Section 3	No compensatory ponds constructed to date					Compensatory ponds constructed in March and April 2020 with locations to be provided in November 2020.
Section 6	No compensatory ponds constructed to date					Compensatory ponds constructed in mid to late 2020 with locations to be provided in November 2020.

Site	Ch. + Side of Carriageway	Number of Constructed Ponds	First Survey	Second Survey	Third Survey	Comments
Section 7	No compensatory ponds constructed to date					No compensatory ponds constructed to date

5.3.6 Connectivity Structure Monitoring

Only one of the nominated connectivity structures for Green-thighed Frog was not under construction during this round of monitoring (Table 5-3). At ch. 19180 (Site 2A), no Green-thighed Frogs were captured whilst the culvert structure was flooded at the time of the survey (Plate 5-5). The structures within Section 2 were under construction and as such were not surveyed.

Plate 5-7. Connectivity structure at ch.19180 during surveys on 20th January 2020 following heavy rainfall.

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

Chainage	Structure Type	Length / specs	Frog Fence	Number of Green-thighed Frogs (toe-clip) Left hand is east side. Right hand is west side.	Comments
19180	RCBC	3.0 x 3.0 x 50 m	1900 to 19400 (400 m)	No captures	Culvert tends to flood during rainfall periods that are suitable for Green-thighed Frog breeding. Green-thighed Frog don't tend to swim around in large ponds or streams of free standing/ flowing water.
24570	RCBC	3.0 x 3.0 x 23 m	24500 to 25000 (500 m)	Not surveyed	Site under construction. Contractor working on underpass.
27420	RCBC	3.0 x 3.0 x 40 m	27420 to 28000 (580 m)	Not surveyed	Site under construction. Contractor working on underpass.
35075	RCBC		34200 to 35200 (1000m)	Not surveyed	Scheduled to commence in 2020/21 season
37330	RCBC		36100 to 38300 (2200 m)	Not surveyed	Scheduled to commence in 2020/21 season
64400	Arch		64200 to 65100 (900 m)	No captures	Surveys focus on western side of the carriageway
102670	RCP		102100 to 102600 (500 m)	No captures.	Scheduled to commence in 2020/21 season
111750	RCP		111800 to 112100 (300m)	No surveyed	Scheduled to commence in 2020/21 season
111756	RCP		111800 to 112100 (300m)	No surveyed	Scheduled to commence in 2020/21 season
118464	Bridge - Tabbimoble floodway	20 m	118100 to 118600 (500m)	No captures	Scheduled to commence in 2020/21 season

5.3.5 Frog Fencing

No Green-thighed Frogs were recorded on the road side of the installed permanent fencing at Site 1A (Falconers), 2A (Halfway Creek), 3A (Bald Knob Tick Gate Road) and 5A (Franklins Road; Table 5-4). At Site 4A (ch.26200), the permanent frog fence had been removed and no temporary frog fence had been reinstated (Plate 5-6).

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). The most notable of these sites is Halfway Creek (Site 2A) where the road side table drain continues to attract frogs with many tens of individuals finding a way through or over the fence or permanently inhabit this area (Plate 5-7). Most of the frog fence extents contain sections where the bottom return is not always fixed to the ground (Plate 5-7).

Further north, monitoring of the fence extents has ceased until construction has been completed.

Plate 5-8. Monitoring site 4a where permanent frog fence has been removed.


Plate 5-9. Examples of frog fence not been fixed to the ground adjacent to frog monitoring sites at Site 1A Falconers (left) and Site 2A Halfway Creek (right).

Table 5-4. Summary of permanent frog exclusion fence monitoring during Year 5 at Sites 1-5 and for Year 4 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
Redbank Creek (Not a BACI monitoring Site)	5600 East	Completed permanent fence	5500-5625	Nil	Nil	Some minor breaches and finishing attention at tie in points to culvert and directional changes required. Majority of other frog species found on habitat side indicating frog fence is effective at reducing but not preventing frog movements onto the carriageway.
Falconers (Site 1A)	11800 West	Completed permanent fence	11700-11850	Nil	Nil	Steep batter associated with this area probably improves the functionality of the fence but numerous points where mesh does not connect with the ground (Plate 5-7).
Halfway Creek (Site 2A)	19100 West	Completed permanent fence	19000-19500	Nil	Nil	Deep table drain on road side appears to attract frog fauna. Number of breach points at turn points and ties to culvert areas plus gaps with mesh on ground (Plate 5-7).
Bald Knob Tick Gate Road (Site 3A)	25000 East	Completed permanent fence	24500-25000	Nil	Nil	First time fence area has been surveyed in conjunction with newly constructed ponds.
Old Highway Heavy Vehicle	26200 West	Completed permanent fence removed	26100-26250	Nil	Nil	Permanent frog fence has been removed.

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
Checking Station (Site 4A)						
Franklins Road (Site 5A)	28000 East	Completed permanent fence	27900-28050	Nil	Nil	Some minor breach points in the fence but considered effective at reducing frog movements out onto the carriageway. Access road with grid that still enables frogs to access roadway
Pheasant Creek (Site 6A)	35200	Not completed				Monitoring to recommence at completion of construction.
Old Six Mile Lane (Site 7A)	38000	Not completed				Monitoring to recommence at completion of construction.
Tyndale Crown Reserve (Site 8A)	64700	Completed permanent fence	64600-64750	Nil	Nil	Monitoring to recommence at completion of construction.
Jackybulbin (Site 9A)	102500	Completed permanent fence	102100 to 102600	Nil	Nil	Monitoring to recommence at completion of construction.
Tabbimoble North (Site 10A)	118500	Completed permanent fence	118100 to 118600	Nil	Nil	Monitoring to recommence at completion of construction.

5.4 Discussion

Green-thighed Frog monitoring over the 2019/2020 season continues to result in frogs being detected at most but not all of the monitoring sites. Detecting frogs at Falconers (Site 1A), Halfway Creek (Site 2A), Glenugie Old Heavy Vehicle Checking Station (Site 4A) and Tabbimoble (Site 10A) continues to prove difficult, even after what could be considered an excellent survey season. At Falconers (Site 1A), frogs tend to be sporadic with the last few recordings made adjacent to the installed compensatory ponds on private land, some of which has now been cleared and currently under blue berry production. Frogs probably still occur in this area, however, they may have shifted to another location to breed and have gone undetected during monitoring which focuses on a specific area. Sampling over an area 500 m either side of the ponds would be required to determine if frogs still inhabit the road corridor as they had done prior to the Upgrade.

Frogs at Halfway Creek (Site 2A) have undergone a decline from 2015 when two males and five other individuals were recorded along this section of the highway using the table drain and associated low lying areas before the Upgrade (Lewis 2015). Since then, there has only been very small numbers (i.e. <3) with a reduction in both calling males and the number of individuals observed. Whilst compensatory ponds have been constructed in accordance with the TFMP and adjacent to an underpass structure, no frogs have selected these as breeding sites. Monitoring of the ponds themselves have shown they tend to dry too quickly to enable tadpoles to reach metamorphosis. The longitudinal drains that has been installed adjacent to the north bound carriageway appear to move water away from this area much quicker than it had in the past.

Further north at Site 4A (Glenugie Old Heavy Vehicle Checking Station), this site has not recorded frogs since the pre-construction surveys of 2013. Even then, frogs were calling from a range of micro habitats on both sides of the old carriageway and there was no clear well defined breeding site like locations to the north at Franklins Road where Site 5A is located or where Site 3A has been relocated to Bald Knob Tick Gate Road. Since the Upgrade, the site has been isolated by the north and south bound carriageways and only inhabited by more common frog fauna. Frogs may return to this area in due course as the population extends for hundreds of metres to the west.

Site 10A (Tabbimoble north) proved difficult to locate frogs during this round of monitoring. This is partly due to the fact that the pronounced pond was an old borrow pit which had been removed to accommodate the north bound lanes of the Upgrade. Surveys this season focused on the flooded drainage line and stump holes from windblown trees further upslope as well as some survey around the underpass structure. Neither contained frogs and whilst they still probably occur in this area, their alternative breeding site remains undetected. Cane Toads were recorded for the first time at this location. Some targeted surveys may be required to confirm their continued presence in the area.

Sites 3A (Bald Knob Tick Gate Road), 4B (Glenugie East), 5A (Franklins Road), 5B (Bom Bom State Forest), 6A (Pheasant Creek), 6B (Airport Road), 7A (Six Mile Lane), 7B (Glenugie East), 9A (Jackybulbin), 9B (Tabbimoble East) and 10B (Glencoe Road) all recorded frogs in and around the usual breeding sites, although not always around the

constructed compensatory breeding ponds, such was the case at Redbank Creek (ch.5500) where frogs now tend to concentrate near the McLaughlin Road overpass around 750 m to the north. The numbers of frogs present at most of these monitoring sites was much higher than had been recorded in the past and this held true regardless of whether the measure of abundance was calling males or simply the number of frogs observed. The observation of two calling male frogs and a female around 1-2 m further away from the constructed ponds at Site 3A was encouraging yet post breeding surveys were unable to confirm this was a success. A disused borrow pit around 30 m away remains the focal pond for Green-thighed Frogs in this area.

This round of monitoring coincided with follow up rainfall, and with that a degree of breeding success across more sites than had been previously recorded during the monitoring program. Whilst this only partially extended to the installed compensatory breeding ponds most sets of ponds functioned in a manner that is consistent with the design objectives of being fish free and drying intervals of 40-60 days. The ponds at Halfway Creek (ch. 19180) however continue to dry too quickly and require some form of intervention (i.e. bentonite lining) as has been proposed during previous monitoring events (i.e. Lewis 2019). The corrective actions applied at Falconers (ch. 11800) appear to have addressed the problems outlined in previous monitoring reports so no further remediation is required at this point in time.

For the remaining sites, compensatory ponds are scheduled for completion in 2020 and will be subject to monitoring in 2020/2021.

How the data collected for Year 4 and 5 compares or performs against the prescriptions outlined in the Threatened Frog Management Plan is outlined in the following section.

5.5 Performance Measures and Corrective Actions

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

Monitoring during the 2019/2020 season includes the population monitoring component as well as some of the compensatory ponds at some, but not all of the sites. Underpass structure monitoring and permanent frog fence monitoring also forms part of the performance related monitoring where structures and permanent frog fencing has been completed.

5.5.1 Population Monitoring

The performing factor for the population monitoring is the number of frogs recorded following a recommendation from earlier surveys (Lewis 2017). Most sites recorded sufficient numbers of frogs with counts among the highest since monitoring began in 2013 (Table 5-5). At the remaining three sites, the recorded absences in Year 5 reflect poorly selected monitoring sites at 1A and 4A as frogs are likely to occur across the wider area and there is no distinct breeding site (Lewis 2013 a,b). These sites were selected as part of developing a monitoring program for Green-thighed Frog (*see* Niche 2014). Natural variation as frogs seek out new or alternative calling sites may explain the reported decline at those two sites, however, this could only be substantiated via targeted surveys at nearby (i.e. <500m) suitable locations to demonstrate the immediate population has not disappeared during the course of the Upgrade. Meanwhile, Site 2A has undergone a continued decline to the point frogs are now absent and this could be linked to the improved drainage as a result of the Upgrade (Table 5-5). Again, targeted surveys of adjacent areas may be required to demonstrate the population that comprised many tens of frogs in 2013 has not disappeared as a result of the Upgrade. Further north at Site 10A (Tabbimoble North), the disused borrow pit was removed to accommodate the north bound carriageway and subsequent monitoring hereafter has been unable to identify any new or alternative breeding site. General traverses of up to 1 km west of this area show a number of suitable breeding ponds associated with low lying depressions along a drainage line and these should be investigated further via some targeted surveys (i.e. alter survey method at this location to confirm continued presence of the population).

5.5.2 Connectivity Structures and Permanent Frog fencing

Surveys performed at one of the connectivity structures found no frogs (Table 5-5). 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 fence surveys tied into this connectivity found no frogs on the carriageway side of the fence, although a number of potential breach points were observed at Redbank Creek, Site 1A and 2A (Plate 5-7). At Site 4A, the permanent frog fence had been removed (Plate 5-6).

5.5.3 Compensatory Breeding Ponds

Surveys were unable to detect Green-thighed Frogs using the compensatory ponds at Redbank Creek (ch5600E), Falconers (ch11800W) and Halfway Creek (ch19100W), ponds that have been installed and monitored now for 3 years.

The ponds at Redbank Creek may have been constructed adjacent to where Green-thighed Frogs have recently been recorded. In previous years, Green-thighed Frogs have been recorded on the western side of the carriageway at Redbank Creek and several hundred metres to the north near the McLaughlin Bridge overpass. Habitat adjacent to the ponds appears suitable but surveys beyond the road corridor are not possible due to access constraints. Importantly, the constructed ponds dry at differing rates and all periodically dry out which has prevented their uptake by mosquito Fish which occur in Redbank Creek, mere metres away.

The ponds at Falconers have received some remediation works so some further monitoring is required before an assessment can be made on their overall suitability as a compensatory pond site. Other frogs tend to use the ponds but monitoring at this site is hampering by the overall disappearance of Green-thighed Frog from this location. Ponds are drying at an acceptable rate of 40-60 days but seem more reliant on follow up rainfall than at other sites.

The ponds at Halfway Creek dry too quickly to be considered reliable breeding habitat for Green-thighed Frog. A bentonite application could slow the drying process and improve the ponds overall suitability. Their use by Green-thighed Frog is hampered by the apparent decline from many tens of calling males in 2013 (*see* Lewis 2013b) to very small numbers of frogs (i.e. <3) over the past few rounds of monitoring.

Ponds were constructed in late winter 2018 at Bald Knob Tick Gate Road and monitored for the second time with some degree of success, two males calling from one pond and a female frog 1-2 m away. Follow up surveys were unable to confirm success via tadpoles, metamorphs or juveniles, however, some of these were found at the nearby disused borrow pit.

Ponds are in their final stages of construction in Sections 3-7 and this should satisfy the commitments identified in TFMP "*where breeding habitat will be directly impacted by the project or changed hydrological patterns have the potential to affect the suitability of breeding habitat areas adjacent to the corridor*".

5.5.4 Riparian Habitat Revegetation

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

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

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2019/20 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Population Monitoring					
The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys. 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: • 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).	Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance. Investigate effectiveness of frog exclusion fencing immediately. Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation. 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.	Relevant	Green-thighed Frogs recorded from impact sites of 3A, 5A, 6A, 7A, 8A and 9A and from reference sites 2B, 3B, 4B, 5B, 6B, 7B, 8B, 9B and 10B. Green-thighed Frogs absent from impact sites of 1A, 2A, 4A, and 10A, and control sites 1B. At Site 1A, frogs have not been recorded since Year 3. The updated baseline survey in 2015 was not able to detect either calling males nor observe individuals despite an earlier survey in 2013 recording some calling males. At Site 2A, the numbers of both calling males and frogs observed at declined from 2 and 5 in the baseline survey to nil frogs since Year 3. At Site 4A, no frogs have been recorded at this location since the 2013 design surveys, including the 2015 updated baseline survey and for the five	Site 1A and 4A were poorly selected monitoring sites. Frogs are likely to still occur in the immediate area (i.e. <500 m). A targeted survey is required to confirm this. At Site 2A, improved drainage from the Upgrade has reduced drying periods for temporary flooded depressions and drains where frogs used to use as breeding sites.	Site 1A, 4A – Perform some "one off" targeted surveys to confirm continued presence at these locations during suitable conditions. Site 2A requires corrective actions. Review of monitoring methods has identified a need for an additional one off survey to confirm presence in this area. Monitoring of the habitat has shown breeding sites dry too quickly and this requires some management (see below). At Site 7A, compensatory ponds should have now been constructed.

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2019/20 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
			monitoring years thereafter. At Site 7A, numbers of frogs have declined by 73-85% since the area has been cleared to accommodate the Upgrade. Partly mirrored by adjacent reference site which has recorded a 44-92% decline. At Site 10A, frogs have disappeared from this site when small numbers were recorded during the baseline survey but not since. Breeding site was removed to accommodate north bound carriageway.	At Site 7A, improved drainage may currently contribute to reduced numbers. The adjacent reference site also drains quickly. At Site 10A, loss of breeding pond and no new pond detected despite some suitable areas.	At Site 10A – Perform some "one off" targeted surveys to confirm continued presence at these locations during suitable conditions.
Underpass Structure Monitoring					
The use of the structure by less than 1% of the estimated population size. Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.	Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified. Survey habitat adjoining the connectivity structures and undertake Landscape improvement (planting, weed removal) to improve habitat functionality. 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.	Relevant	Surveys performed at one of the connectivity structures (19100) where no frogs found. All other nominated structures under construction.	Commencement of mark recapture works to be assessed in following years.	Nil

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2019/20 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
	Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.				
Constructed Pond Monitoring					
Absence of threatened frogs and metamorphs at the compensatory ponds after three years since construction.	Investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (i.e. 3 more years of monitoring) Review monitoring methods, considering timing and weather conditions to ensure individuals are identified. Review location of the compensatory pond and consider moving, and/or modifying or constructing additional ponds. Investigate habitat adjoining the upgraded highway and consider improving habitat condition and connectivity.	Four rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over four seasons at three sites and two season at Site 3A. At Sites 6-10 no ponds have been constructed/monitored to date.	No use recorded at Redbank Creek, Falconers and Halfway Creek. Two males and a female frog recorded from one pond at Bald Knob Tick Gate Road in mid January 2020. Follow up surveys were unable to confirm breeding success. No ponds constructed in Sections 3-7 yet commitments identified in TFMP.	Frogs have been recorded to the north of Redbank Creek at McLaughlin Road overpass. May be other suitable locations for breeding nearby but access constraints prevent surveys through much of this area. Ponds at Falconers provide frog breeding habitat. Likely to be other similar habitat used by frogs in locality (i.e. <500m). Ponds at Halfway Creek dry too quickly without regular follow up rain. Could be partly addressed via a bentonite application to slow drainage. Ponds at Bald Knob Tick Gate Road (ch. 25000) are new and shows signs of use in their second season. Frogs recorded successfully breeding 30 m away in borrow pit. Use of existing depressions at Franklins Road (ch. 28000) found frogs bred successfully at this location in Year 5.	1. Halfway Creek ponds 19180 - corrective action point 3 “modify” via the use of bentonite to reduce drying time of ponds. 2. Construct ponds in Section 3 so that monitoring can commence in those areas where breeding habitat has been removed (i.e. Section 3, 7).
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.	Comparable to surrounding habitat.	Nil

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2019/20 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
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	Four rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over four seasons at three sites and two season at Site 3A. At Sites 6-10 no ponds have been constructed to date.	Ponds held water at variable rates and considered to have met design intentions at Redbank Creek, Falconers and Bald Knob Tick Gate Road but not at Halfway Creek (ch.19180). No ponds constructed in Sections 3-7 yet commitments identified in TFMP.	Sandy soils at Halfway Creek equate to shorter drier periods. Proximity of services and the project boundary limit the extent and location of ponds.	1. Halfway Creek ponds ch.19180 - corrective action “apply physical corrective actions” via the use of bentonite to reduce drying time of ponds.
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.	Four rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over four seasons at three sites and two season at Site 3A. At Sites 6-10 no ponds have been constructed to date.	No Mosquito Fish recorded.	Ponds are drying out to ensure they remain fish free.	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.	Four rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over four seasons at three sites and two season at Site 3A.	1. Ponds at Redbank Creek, Falconers and Bald Knob Tick Gate Road functioning as suitable frog breeding habitat. 2. Ponds at Halfway Creek drying too quickly and require rectification works. The longitudinal table drain beside	At Halfway Creek, longitudinal drains act as a sump to the surrounding area and increased drying times. Difficult area to position ponds away from other infrastructure and services whilst the project boundary is in close proximity.	1. Add bentonite or some similar product to retard drying times so they accord more with larval development of Green-thighed Frog of 40-50 days.

Triggers for corrective actions	Corrective actions	Relevance to 2019/20 Green-thighed Frog Monitoring	Results of 2019/20 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
		At Sites 6-10 no ponds have been constructed to date.	carriageway has increased drainage in this area and requires compensatory measures for Green-thighed Frog.		
Revegetated native habitat in poor condition (e.g. >30% cover died, plant dieback).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Not relevant.	Not Applicable	Not Applicable	Not Applicable
Frog absence confirmed following monitoring surveys (it should be noted that a pond may be suitable for frogs, but not colonised).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Relevant	Redbank Creek, Falconers and Bald Knob Tick Gate Road – ponds are constructed in a suitable manner and considered functional. Halfway Creek – Ponds dry out too quickly.	At Halfway Creek, longitudinal drains act as a sump to the surrounding area and increased drying times. Difficult area to position ponds away from other infrastructure and services combined with close proximity of the project boundary.	Halfway Creek - add Bentonite or some similar product to retard drying times so they accord more with larval development of Green-thighed Frog of 40-50 days.
Riparian Habitat Revegetation					
Greater than 10% of riparian plants have died after first 12 months of maintenance. Greater than 20% of riparian plants have died after three years of maintenance. Total weed coverage is more than 30% in revegetation areas. Bank erosion causes unforeseen revegetation area instability.	Review maintenance schedule for revegetated areas immediately after trigger. Replace dead plants within one month of issue being identified. Increase weed control if required as soon as practicable or review control methods being used. Install physical measures to halt bank erosion within one month of issue being identified.	Not relevant – locations are not within riparian zones.	Not relevant	Not relevant	Not relevant

5.6 Conclusions and Recommendations

Monitoring for the Green-thighed Frog was triggered by heavy rainfall in mid January 2020 for most of the sites located between Corindi and New Italy. As this rainfall was triggered by a broad weather system, it allowed surveys to be conducted over the entire study area, something that has not happened for the past few monitoring events. A second similar weather system delivered well in excess of 100 mm in early February 2020 and this enabled the remaining sites to be surveyed between Corindi and Grafton which had been the focus of restricted access or had been surveyed at the tail end of the earlier weather system.

Frogs were recorded at 15 of the monitoring sites including six impact sites and included some encouraging numbers of frogs from most of these sites, particularly further north at Jackybulbin where Site 9A was burnt by the Myall Creek wild fire in November 2019, yet numbers of frogs were the highest since monitoring begun in 2015. There are however, a number of continuing declines and absences which have now continued for the past three consecutive monitoring events and in some cases, since monitoring began. At Site 1A (ch11800), male frogs were heard calling from nearby private property which has since been developed for intensive agriculture, so the reported declines here may be linked to impacts other than the Upgrade. Site 2 (ch.19100) has declined from five frogs in the baseline survey to just one individual in Year 3, and now no frogs in Year 4 and 5. Earlier surveys of this site in 2013 recorded many tens of calling males and hundreds of individuals (Lewis 2013). Some targeted surveys are warranted to determine if a population remains in the general area (Table 5-6). Similar absences have occurred further to the north in Section 2. At Site 4A (Old Southbound Heavy Vehicle Checking Station), frogs remain absent since the 2015 baseline survey and have continued to do so for the entire monitoring program. Frogs probably remain in this area, and this should be explored via some targeted surveys to confirm the populations hasn't disappeared during the course of the Upgrade (Table 5-6). Further north, frogs remain absent at Site 10 A (Tabbimoble North) where construction has removed the previously monitored breeding site and an adjacent ephemeral gully now forms the focal point for surveys. Toads have now been recorded in this area, and with that, increased competition for tadpoles and predation of the frogs themselves. Again, a targeted survey would prove useful to locate the population and enable more informed monitoring to continue (Table 5-6).

Monitoring of the constructed compensatory frog ponds found some encouraging evidence of frogs using the newly constructed ponds at Site 3A off Bald Knob Tick Gate Road where two males were calling from one of the ponds and a female frog was observed 1-2 m away. Follow up surveys were unable to confirm breeding success at this site whilst the adjacent disused borrow pit recorded a number of juveniles and a couple of tadpoles reaching metamorphosis. Meanwhile, surveys at the remaining sites continue to find no evidence of Green-thighed Frogs using any of the ponds at Redbank Creek, Falconers and Halfway Creek but to be fair, these sites are supported by few and at times no Green-thighed Frogs. Based on design principals of water retention, variability in drying times and the adequacy of calling points, they do appear functional. At Halfway Creek, the previously reported problem of the ponds drying too quickly still exists and this requires attention now that four consecutive monitoring periods (including three operational years) have recorded no frogs and ponds continue to dry too quickly for tadpoles to reach metamorphosis. The longitudinal drains constructed

to move water away from the carriageway have reduced the time water ponds in this area, and with this, we may see a broader change to the surrounding plant community types. The application of bentonite or some other similar product is a recommended corrective action at this location.

Monitoring of the retained breeding habitat at Franklins Road (Site 5A) found frogs selected the more natural undisturbed ponds on this occasion and with that successful breeding was recorded. Part of this was attributed to the follow up rains in early February. Surveys of the frog fence found no Green-thighed Frogs on the road side which has now been the case for the past three years, whilst the connectivity structure was under construction and not considered finished to enable monitoring.

The performance indicators of the monitoring program were updated to reflect the actual number of frogs recorded rather than relying on the numbers of calling males (*see* Lewis 2017). Monitoring has detected declines that have exceeded the acceptable 25% threshold at Site 2 (Halfway Creek) and Site 10 (Tabbimoble North) where frogs have now disappeared from both sites for more than three consecutive monitoring events. A simple remedy of performing a targeted survey of the surrounding area to confirm continued presence of the population has been recommended (Table 5-6). The reported decline at Site 7 (Old Six Mile Lane) is a little more difficult to interpret with the impact treatment decline by 73% in Year 4 compared to a 44% decline at the adjacent reference site. There is concern about the overall changes to localised hydrology following the construction of the carriageway, something that should be considered further during the operational monitoring.

Monitoring of the installed permanent frog fencing indicates Green-thighed Frogs remain on the habitat side of the fence. This has now been the case for three consecutive monitoring events at Sites 1-5 in Section 1 and 2. Although other types of frogs were found on the carriageway side of the fence and quite possibly inhabit these areas on a permanent basis, many more were found on the habitat side. Addressing the reported breaches outlined in this report would improve the effectiveness of reducing frog movements onto the carriageway, but is unlikely to entirely eliminate it.

Monitoring of the connectivity structures was limited to a single structure at Halfway Creek (Site 2A) where no Green-thighed Frogs were found. The remaining structures in Section 2, 3, 6 and 7 will require monitoring in the future to assess their overall effectiveness of restoring habitat connectivity as a result of the Upgrade.

Based on the 2019/20 findings, the following recommendations and Transport for NSW responses have been presented in Table 5-6.

Table 5-6. Recommendations following 2019/20 Green-thighed Frog monitoring and Transport for NSW responses.

Recommendation No	Recommendation	Transport for NSW Response
1.	Bentonite or similar additive applied to the compensatory ponds at Halfway Creek (ch. 19180).	Adopted - Remediation works such as a bentonite layer will be applied to these ponds.
2.	TfNSW inspect fences for reported breach points at Site 1A, 2A, 3A, 5A, 8A, 9A and 10A.	Adopted - Fencing at 8A, 9A and 10A are still under construction during the reporting period and are not considered defect free. For sites 1A, 2A, 3A and 5A TfNSW will repair identified breach points.
3	The compensatory Green-thighed Frog breeding ponds be identified in Sections 3-8. The TFMP currently notes "*These will be constructed where breeding habitat will be directly impacted by the project (Figure 3-1 and Figure 3-3) or changed hydrological patterns have the potential to affect the suitability of breeding habitat areas adjacent to the corridor*".	Noted - Ponds will be installed as per the TFMP. All ponds have now been installed apart from Section 7 which are in the final stages of installation. Once all ponds are installed monitoring can commence.
4	Conduct broader surveys at Site 1A (Falconers), Site 2A (Halfway Creek) and Site 10A (Tabbimoble north) to confirm continued existence of the population. Survey design should consist of a one off 60 min survey at each location during suitable weather conditions.	Site 1A (Falconers) - Not adopted - Baseline is 0 and therefore it's not possible to record a decline. This site also influenced by blue berry production as noted in this report. Site 2A (Halfway Creek) - Adopted - Support undertaking one off broader survey to confirm presence to conclude population monitoring for GTF in Sections 1 and 2. Site 10A (Tabbimoble north) - Adopted based on data exceeding corrective performance measure.

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7.0 APPENDIX A – RAW FROG SURVEY AND RAINFALL DATA

Table A1. Raw Year 5 Giant Barred Frog survey data.

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

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

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing	
2B	Pigeon Gully	5/02/2018	2040	2220	19	17	100	85	0	1		0															
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Male	Adult	Light nuptials	65	13	000735C3E3	120m-DS	9	Second time recapture from Year 2	Observed	Above litter	Northern bank	Originally tagged as a sub adult in Year 2 so its Year adult male		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	48	13.5	000735CF3H	120m -DS	6	First time	Observed	On sand	Northern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	49	12.5	000735BD8D	100m -DS	4	First time	Observed	On sand	Southern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	47	17.5	0007358D8F	120m - DS	4	First time	Observed	Above litter at base of Lomandra	Southern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	50	16	00073579D3	90m- DS	3	First time	Observed	On sand of scoured bank	Edge of powerline easement - Northern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	45	13	000735876C	50 m downstream	4	First time	Observed	Above litter on scoured bank	Northern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Male	Adult	Very Dark Nuptials	74	46	000735B008	construction site	3	Second time	Observed	On sand	Northern bank	Recapture from similar area during Year 2		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Male	Adult	Dark Nuptial	81	65	000735CB6F	30m -US	4	Fourth time recapture	Observed	Above litter	Southern bank	Appears to be a dominate male frog recaptured for the fourth time		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	53	17	000735CF3D	40m - US	5	First time	Observed	Above litter	Southern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	46	11.5	0007352C9F	10m -US	2	First time	Observed	On bare bank	Southern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	50	16	0007356376	100m - US	5	First time	Observed	Above litter	Southern bank			
												3 sub adults and 2 adults missed															
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Juvenile	Immature	37	4	735AE69	40m - DS	1	First time	Observed	Above litter	Southern bank	506519	6690536	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	82	64	735841E	30m - DS	2	Recapture	Heard	Part buried in litter and sand	Northern bank	506528	6690533	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Sub Adult	Immature	48	47	735c72B	70m - DS	1	First time	Observed	Above litter	Northern bank	506509	6690554	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	82	47	735c02C	90m - DS	1	First time	Observed	Above litter	Northern bank	506492	6690654	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Sub Adult	Immature	51	13	73593ED	90m - DS	3	First time	Observed	Above litter	Northern bank	506495	6690567	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	98	60	735b8F8	90m - DS	4	First time	Observed	Above litter	Northern bank	506495	6690567	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Sub Adult	Immature	46	8	735A512	180m - DS	1.5	First time	Observed	Above litter	Southern bank	506412	6690540	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	81	54	7358DEB	120m -DS	3	First time	Observed	Above litter	Southern bank	506455	6690551	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	80	50	735C00A	50m -DS	10	First time	Observed	Above litter	Southern bank	506477	6690548	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle.	19	Female	Sub Adult	Immature	50	13	7355AB6	50m - DS	2	First time	Observed	On sand	Southern bank	506520	6690526	

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing	
											Some ponds stagnant																
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	78	52	7353DFE	65m - US	1	First time	Heard	On sand	Northern bank	506635	6690514	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	74	46	7359648	70m - US	0	First time	Heard	on water's edge	Northern bank	506639	6690515	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	83	46	735A52f	70m -US	2	First time	Heard	on log	Northern bank	506663	6690520	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Dark Nuptials	72	41	7352F38	105m -US	4	First time	Observed	Above litter	Southern bank	506714	6690505	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Gravid	118	144	7353 e 11	200m -US	3	First time	Observed	under litter	Southern bank	506826	6690470	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Juvenile	Sub Adult	Immature	46	8.5	73586AB	115m-US	3.5	First time	Observed	Above litter	Southern bank	506749	6690502	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	60	17	735629b	80m-US	3	First time	Observed	on moss	Northern bank	506701	6690507	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Dark nuptials	75	38	735B701	80m-US	3	First time	Heard	Above litter	Northern bank	506701	6690507	
												1 adult male heard calling but not often enough to be located															
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Moderate nuptials	82	58	0007357E1B	30m - DS	5	Second time	Observed	Above litter	Northern bank	Recapture from Year 2		
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Moderate Nuptials	75	47	0007352FFD	50m - DS	4	First time	Observed	Above litter	Northern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Light nuptials	73	55	00073577DF	120m - DS	3	First time	Observed	Above litter	Southern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Dark nuptials	80	46	0007352CCF	190m - DS	6	First time	Observed	On log	Southern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Unknown	Sub adult	Immature	52	19	0007358F95	190m - DS	5	First time	Observed	Above litter	Southern bank			
3B	Yellow Crossing Road (Wooli	11/11/2017	28	0340	17	17	60	83	0	1		12	Female	Adult	Not gravid	104	120	000735C4BF	220m - DS	7	Second time	Observed	Above litter	Northern bank			

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing	
	River Catchment)																										
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Light nuptials	74	55	0007358C90	100m - DS	5	First time	Observed	Above litter	Southern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Female	Adult	Not Gravid	93	88	0007359C55	15 m - US	8	First time	Observed	Above litter	Northern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Moderate Nuptials	74	48	0007358944	40 m - US	5	First time	Observed	Above litter	Northern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Unknown	Sub adult	Immature	50	18	0007357CB3	100m -US	5	First time	Observed	Above litter	Southern bank			
												2 sub adults missed															
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Unknown	Sub adult	Immature	47	7.5	7356534	30m - US	5	First time	Observed	Above litter		515423	6689075	
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Female	Adult	Gravid	110	159	7359AFD	150m - US	5	First time	Observed	Above litter		515325	6689070	
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Female	Adult	Not Gravid	101	124	73530f8	220m -US	2	First time	Observed	Above litter		515300	6689097	
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Female	Adult	Not Gravid	80	50	735BAFD	230m - US	4	First time	Observed	Above litter		515300	6689093	
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Unknown	Sub adult	Immature	42	7	735b50e	50m - US	5	First time	Observed	Above litter		515390	6689088	
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Unknown	Sub adult	Immature	48	8	735967f	30m - US	3	First time	Observed	Above litter		515411	6689083	
												1 male calling upstream could not be located															
4A	Boneys Creek	14/11/2017	2113	2255	21	17	40	77	0	1	Series of pools	1	Unknown	Sub Adult	Immature	52	16	0007357BF9	60 m downstream of construction works	5	First time	Observed	Above litter	Southern bank			

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing	
4A	Boney's Creek	8/02/2014	23:00	2:00	20	17	0	90	0	0	Shallow, little water movement.	3	Male	Adult	Moderate nuptials	71	42	735C0E1	10m - DS	0.5	First time	Heard	in grass		512478	6686214	
4A	Boney's Creek	8/02/2014	23:00	2:00	20	17	0	90	0	0	Shallow, little water movement.	3	Female	Adult	Gravid	115	166	735B4E9	210m - DS	10	First time	Observed	Above litter		512445	6686351	
4A	Boney's Creek	8/02/2014	23:00	2:00	20	17	0	90	0	0	Shallow, little water movement.	3	Female	Adult	Not gravid	101	124	73587CC	190m - DS	5	First time	Observed	Above litter		512424	6686355	
4B	McPhillips Road	14/11/2017	2317	111	19	17	50	86	0	1	Series of shallow pools	1	Female	Adult	Not gravid	70	52	0007359B0C	10 m upstream of McPhillips Road	5	Second time	Observed	On bare ground	Southern Bank			
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	Light nuptials	71	37.5	735BC4a	115m - US	1	First time	Observed	Above litter		513086	6686332	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Female	Adult	Not gravid	69	27	735B001	120m - US	1	First time	Observed	Above litter		513074	6686323	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Female	Adult	Not gravid	92	81	735A516	150m - US	1	First time	Observed	Above litter		513078	6686314	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	dark brown	84	64	735C3E4	170m - US	4	First time	Observed	Above litter		513091	6686298	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	dark brown	80	55	735AA6B	180m - US	5	First time	Observed	Above litter		513107	6686293	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	pale brown	82	55	735C3A2	210m - US	6	First time	Observed	Above litter		513111	6686294	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	pale brown	75	44	7354D0A	210m - US	4	First time	Observed	Above litter		513111	6686304	

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

18th – 19th January 2018											30th – 31st May 2018										
	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	2	0	0	0	0	25	75	1	0	nr	3	1	0	0	210	14	81	0	25	6.2	Most of construction works packed up. Monitoring star pickets removed
1B	1	0	0	0	0	24	77	1	0	nr	1	0	1	0	120	14	80	0	25	4.9	Site continues to provide consistently low numbers of frogs
2A	0	0	0	0	0	25	75	1	0	nr	0	0	0	0	90	15	79	0	30	5.1	Dries too quickly to enable sufficient monitoring.
2B	11	2	0	0	0	25	75	1	0	nr	15	8	3	0	290	15	80	0	30	4.8	Occasional calls during summer survey when site was dry again like the year before.
3A	0	0	0	0	0	24	80	1	0	nr	0	0	0	0	180	14	87	0	25	5.4	Site prone to drying out rapidly and periodic mowing
3B	0	0	0	0	0	24	78	1	0	nr	0	0	0	0	240	15	81	0	25	5.3	Site dry in summer survey but water in second autumn winter survey but still no frogs
4A	1	0	0	0	0	25	74	1	20	nr	3	0	1	0	350	15	81	0	0	6.5	Site maintaining a higher pH than pre construction surveys
4B	0	0	0	0	0	25	76	1	20	nr	2	0	0	0	110	15	81	0	0	5.9	Site dries out rapidly making it difficult to monitor
5A	0	0	0	0	0	27	67	0	25	nr	1	0	0	0	100	14	91	0	0	4.6	Site typically seasonally inundated but dries within weeks to months depending on groundwater levels
5B	8	3	0	0	0	27	70	0	25	nr	19	5	1	0	350	14	91	0	0	4.4	Seems to be a resilent site and form part of core or source population for the nearby impact site.

Table A3. Summary of Green-thighed Frog surveys during the 2018/19 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 Spotlighted	Stage 2 Survey Date	Days After Stage 1 Survey	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
Compensatory Breeding Pond - Redbank Creek	5600	Redbank Creek	E:516564 N:6680284	07.02.2020	2125-2145	23	100	0	2	100	0	0	22.03.2020	44	0	0	0	No	Other frogs using the constructed ponds.
1A	11800	Dirty Creek Range / Falconers	E:503224 N:6685035	07.02.2020	2206-2226	22	95	0	2	100	0	0	22.03.2020	44	0	0	0	No	Site under construction
1A - Compensatory Breeding Pond - Dirty Creek Range (Falconers)	11800	Dirty Creek Range / Falconers	E:513172 N:6685262	20.01.2020	2255-2315	23	83	0	1	30	0	0	29.02.2020	40	0	0	0	No	Constructed ponds held more water for longer during this round of monitoring. Frogs may now use an alternative unknown site.
1A - Frog Fencing	11750-11880	Dirty Creek Range / Falconers	E:513190 N:6685262	20.01.2020	2347-0010	22	85	0	1	25	2	1	29.02.2020	40	0	2	0	Yes	Using side table drain off shoot from main pond.
1B - Old (As per TFMP RMS 2015)	23000	Wells Crossing Beside Road	E:506185 N:6692721	21.01.2020	0023-0045	21	81	0	1	25	11	9	29.02.2020	39	0	7	2	Yes	Using an alternative site near constructed breeding ponds
2A	19100	Halfway Creek	E:507641 N:6689299	21.01.2020	0132-0153	21	83	0	1	25	2	4	29.02.2020	39	0	0	0	No	No clear breeding site at this location just stump holes from fallen trees or grader turn outs
2A Compensatory Breeding Pond	19000	Halfway Creek	E:507644 N:6689255	20.01.2020	0351-0410	20	95	0	1	80	0	0	29.02.2020	40	0	0	0	No	Site under construction
2A - Frog Fencing	18900-19300	Halfway Creek	E:507644 N:6689255	20.01.2020	0257-0318	21	100	0	2	100	18	24	29.02.2020	40	0	15	2	Yes	Site unaffected by recent fires
2B	23000	Yuraygir SRA	E:508694 N:6693816	20.01.2020	2100-2120	24	82	0	1	25	2	6	29.02.2020	40	0	7	3	Yes	Frogs favoured ponds with dense litter and sticks during this breeding event
3A	25800	Bald Knob Tick Gate Road	E:505801 N:6694708	20.01.2020	0432-0455	20	95	0	1	80	9	12	29.02.2020	40	0	7	2	Yes	Ponds retained a lot more water during this round of sampling. Success recorded at nearby borrow pit disused but at least calling males and female showed up at comp. pond.
3B	30000	Glenugie West	E:501553 N:6699052	08.02.2020	0002-0022	22	100	0	2	98	11	15	22.03.2020	43	0	2	0	Yes	Found in small offshoot of drainage line
4A	26200	Glenugie Heavy Vehicle Checking Station South	E:505127 N:6696150	19.01.2020	2010-2025	21	100	0	3	100	20	21	29.02.2020	41	0	17	2	Yes	Held more water given follow up rains
4A - Frog Fencing	26100-26250	Glenugie Heavy Vehicle Checking Station South	E:505167 N:6696111	08.02.2020	0035-0055	22	100	0	2	98	15	13	22.03.2020	43	0	3	0	Yes	Using pond from old stump hole
4B	35000	Glenugie East	E:506326 N:6703965	20.01.2020	0215-0235	21	100	0	2	100	7	14	29.02.2020	40	0	5	0	Yes	Pond almost dry
5A	28000	Franklins Road	E:505038 N:6697387	20.01.2020	0005-0025	21	100	0	2	100	5	2	28.02.2020	39	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
5A - Frog Fencing	27900-28050	Eastern side Franklins Road	E:505014 N:6697324	20.01.2020	0120-0140	21	100	0	2	100	8	6	28.02.2020	39	0	0	0	No	Frogs now appear to favour drainage line to the north
5B	37000	Stokers Road Bom State Forest	E:498275 N:6707681	19.01.2020	2108-2128	22	100	0	2	100	25	26	28.02.2020	40	0	11	0	Yes	Site contained a lot more water than during previous breeding events
6A	35200	Pheasant Creek	E:502672 N:6704172	19.01.2020		2228-2252	22	100	0	2	100	15	13		28.02.2020	40	0	5	2
6B	38000	Airport Road	E:501766 N:6706969	19.01.2020	2145-2200	22	100	0	2	100	0	0	28.02.2020	40	0	0	0	No	Only drainage line and an occasional stump hole from fallen tree provided breeding habitat

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 Spotlighted	Stage 2 Survey Date	Days After Stage 1 Survey	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
7A	38000	Old Six Mile Lane	E:503837 N:6706546	19.01.2020	2145-2200	22	100	0	2	100	3	3	28.02.2020	40	0	0	0	No	Likely to have bred in adjacent area
7B	35000	Glenugie East	E:505733 N:6703338	07.02.2020	2125-2145	23	100	0	2	100	0	0	22.03.2020	44	0	0	0	No	Other frogs using the constructed ponds.
8A	64700	Tyndale Crown Reserve	E:513362 N:6727361	07.02.2020	2206-2226	22	95	0	2	100	0	0	22.03.2020	44	0	0	0	No	Site under construction
8A - Frog Fencing	64600-64800	Tyndale Crown Reserve	E:513362 N:6727361	20.01.2020	2255-2315	23	83	0	1	30	0	0	29.02.2020	40	0	0	0	No	Constructed ponds held more water for longer during this round of monitoring. Frogs may now use an alternative unknown site.
8B	57500	Pine Brush State Forest	E:517300 N:6719708	20.01.2020	2347-0010	22	85	0	1	25	2	1	29.02.2020	40	0	2	0	Yes	Using side table drain off shoot from main pond.
9A	102500	JackyBulbin	E:520731 N:6758742	21.01.2020	0023-0045	21	81	0	1	25	11	9	29.02.2020	39	0	7	2	Yes	Using an alternative site near constructed breeding ponds
9A – Frog Fencing	102100 - 102600	JackyBulbin	E:520731 N:6758742	21.01.2020	0132-0153	21	83	0	1	25	2	4	29.02.2020	39	0	0	0	No	No clear breeding site at this location just stump holes from fallen trees or grader turn outs
9B	111500	Tabbimobile East	E:525262 N:6767265	20.01.2020	0351-0410	20	95	0	1	80	0	0	29.02.2020	40	0	0	0	No	Site under construction
10A	118500	Tabbimoble North	E:527238 N:6772864	20.01.2020	0257-0318	21	100	0	2	100	18	24	29.02.2020	40	0	15	2	Yes	Site unaffected by recent fires
10A – Frog Fencing	118500	Tabbimoble North	E:527238 N:6772864	20.01.2020	2100-2120	24	82	0	1	25	2	6	29.02.2020	40	0	7	3	Yes	Frogs favoured ponds with dense litter and sticks during this breeding event
10B	114000	Glencoe Road	E:524143 N:6769665	20.01.2020	0432-0455	20	95	0	1	80	9	12	29.02.2020	40	0	3	0	Yes	Ponds retained a lot more water during this round of sampling

Table A4. Rainfall data (Grafton Airport - Station 58161) with survey dates (shaded red) for Green-thighed Frog surveys at Sites 1-10 during the 2019/20 monitoring season.

2020	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1st	7.8	0	0	0	0	0.2	0	1.6
2nd	0	0	3.2	0	0	0	0	0.2
3rd	0	0	0.2	0	0	0	0	0
4th	0	0	0	0	12.4	0	26.6	0
5th	0	0	0	0	0	3.4	4.4	0
6th	0.4	0.2	0	0	3.2	2	0	0.4
7th	0	0	0	0	105.8	3.2	0	0.2
8th	0	0	0	0	3.2	0	0	0
9th	0	0	0	0	102.2	0.8	0.6	0
10th	0	0	0	1.8	10.4	4.2	6.6	7
11th	0	0	0.4	0	11.8	0.2	16.2	0.2
12th	8.4	0	1	1.4	25.6	0	0	0
13th	1.4	0	0	0.2	93	0.4	0	0
14th	0	0	0.2	0	17	0	0	0
15th	0	0	0	10.2	0	0.2	0	0.4
16th	0	0	0	1	0	2	0	0
17th	5.4	0	0	21	0	1	0.2	3
18th	0.6	2.2	0	155	6.2	1.8	0	7.8
19th	0	0	0	116.6	0.2	0	0	0.6
20th	0	0	0	0	0	0	0	0
21st	0	0	0	0	0	0	0	0.2
22nd	0	0	0	0	2	0	0	4.8
23rd	0	0	0	0	0	0	0	0
24th	0	0	18.4	9	34	0.4	0	0.8
25th	0	0	11.2	0	4.6	0.4	0	0.2
26th	0	0	6.6	1.8	0	1.4	0	0
27th	0	1.6	0	0.2	7.2	20.6	0.2	0
28th	0	0	0	0	0	0.2	2.6	0
29th	0	0.6	0	0	3.2	7.6	0.2	0
30th	0	8.4	0	0		0.2	0	0
31st	0		0	0		16		0.8
Highest Daily	8.4	8.4	18.4	155	105.8	20.6	26.6	7.8
Monthly Total	24	13	41.2	318.2	442	66.2	57.6	28.2