Transport
Roads & Maritime
Services

Warrell Creek to Nambucca Heads

Green-thighed Frog Monitoring Report – year four operational phase 2021-2022

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1. Introduction

In 2015, Transport for NSW (TfNSW), in conjunction with Acciona Ferrovial Joint Venture (AFJV), commenced the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (WC2NH). The WC2NH project was opened to traffic in two stages:

- Stage 2a - 13.5km section from Lower Warrell Creek Bridge to Nambucca Heads opened on 18 December 2017; and
- Stage 2b - 6.25km section from the southern end of the project to the Lower Warrell Creek bridge opened on 29 June 2018.

Approvals for the WC2NH upgrade required monitoring of several species and mitigation measures during the operational phase. Species and mitigation measures targeted include koala, spotted-tailed quoll, grey-headed flying-fox, yellow-bellied glider, giant barred frog, green-thighed frog (GTF) breeding ponds, fauna underpasses, vegetated median, road mortality, exclusion fencing, and threatened flora. Sandpiper Ecological Surveys (Sandpiper) was contracted by TfNSW to deliver the WC2NH operational ecological and water quality monitoring program.

The green-thighed frog (*Litoria brevipalmata*) is listed as vulnerable under the New South Wales *Biodiversity Conservation Act* (BC Act) *2016*. The project approval required monitoring of specially constructed green-thighed frog breeding ponds. The following report details the results from the fourth monitoring year and discusses findings in relation to the follow performance indicators:

- Continued presence of green-thighed frogs at breeding ponds or individuals calling from the edge of constructed ponds
- The presence of tadpoles, juveniles or metamorphs during follow up surveys

The overall aim of monitoring is to confirm use of the subject ponds by the target species.

1.1 Background

During pre-construction surveys green-thighed frogs were recorded at two locations within/adjoining the WC2NH alignment (Lewis 2013). The locations were:

- Chainage 60065 within the road corridor where two male frogs were recorded; and
- Chainage 60865 eastern side of road corridor where one male frog was recorded.

Low-lying, periodically inundated forest between chainages 57365 and 59365 was identified as potential habitat (Lewis 2013). Based on this information, Lewis (2013) recommended that breeding ponds be constructed at five locations within the WC2NH section (Table 1). Each location was to contain five (approximately) 4 x 3 m ponds with a maximum depth of 400 mm, and a 250 m section of permanent frog exclusion fence was to be installed between the ponds and carriageway. Site 2N was initially situated on the north side of the alignment at chainage 60065 but was moved to chainage 59440 due to concern about vehicle strike on Old Coast Road.

Table 1: Location and features of frog ponds. * green-thighed frog recorded during pre-construction surveys.

Site	Chainage	Easting	Northing	No. ponds	Retention period (days)	Topographic position (as per Lewis 2013)
1E	58015	495912	6607879	5	60-80	Adjacent to drainage line; staggered upslope
1W	58165	495921	6608056	5	60-70	Upper slope/ridgeline
2S	60065*	496795	6609634	5	60-70	Open area
2N	59440	496465	6609092	5	Not specified	Not specified
3	60865*	497383	6610179	5	60-70	Ridge

1.2 Study area

The WC2NH project covers a total length of 19.75km and extends from Warrell Creek in the south to Nambucca Heads in the north (Figure 1). The alignment bypasses the town of Macksville and the northern section traverses Nambucca State Forest. Green-thighed frog breeding ponds are situated at the northern end of the alignment, adjoining Nambucca State Forest (Figure 1).

2. Methods

2.1 Weather conditions

Frog surveys were based on two rainfall triggers:

- 75mm in 24hrs; or
- 150mm in 72hrs.

Since the project weather station was decommissioned in late January 2020 monitoring of rainfall switched to the Bellwood station (N$^{o.}$ 059150) managed by the Bureau of Meteorology (BoM). In late February 2022 a large rain event occurred in north-eastern NSW. Observation of rainfall totals for the Bellwood station reached 81.6mm on 24 February exceeding the survey trigger of 75mm in 24 hours. The 150mm in 72 hr threshold was also later exceeded with a rainfall total of 193.8mm between 26-28 February. Frog surveys occurred on 24 and 28 February.

2.3 Reference site

The reference site referred to in the project brief was sampled during the February 2022 surveys. The site did not contain standing water during the survey, and it seems likely that potential breeding habitat was removed during construction and drainage/remediation work along Old Coast Road. As per the year 2 monitoring report (Sandpiper Ecological 2020) the reference site survey was expanded to include the ridgeline east and west of the alignment at 2S, and the ridge north of site 3 (Figure 2). These surveys included a slow traverse of management trails by two ecologists searching flooded wheel ruts and depressions.

2.4 Frog survey

Breeding ponds were sampled on 24 and 28 February. Surveys were conducted by two personnel and involved a 30-minute active search at each site, including peripheral habitats within 100m of a site. During each survey the littoral zone of each pond was carefully inspected and all calling and observed frogs were recorded. Surveys were conducted between 1945 and 0015 hours. Upon arrival at a site, 5 minutes was spent listening for calling frogs.

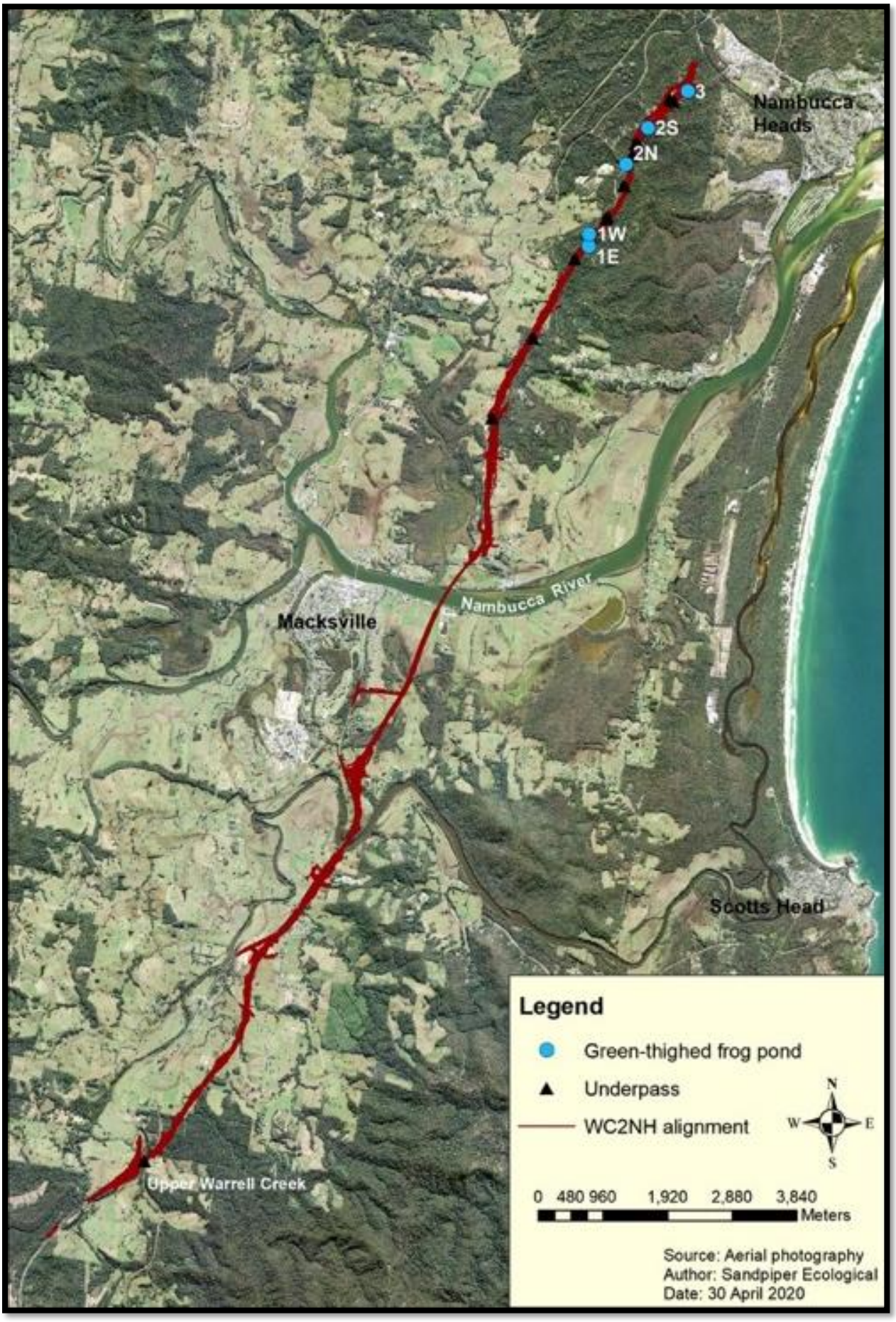

Figure 1: Location of constructed green-thighed frog ponds in relation to the WC2NH alignment.

2.5 Tadpole survey

Tadpole surveys were conducted on 25 March, 30 days after the first February rain event. Tadpole surveys included: a 20-minute traverse of each site focussing on pond edges and immediate surrounds; and dip-netting each pond (10 scoops/pond). Other data collected were: water depth at post; and photo of each pond array. A map of each site was prepared showing the location of ponds in relation to the forest edge, highway and drainage lines. Frog exclusion fence at each site was inspected for evidence of gaps or deterioration.

Captured tadpoles were transferred to an aquarium for identification using Anstis (2017). Fish were identified with reference to Allen *et al.* (2002) and dytiscid larvae with reference to the Centre for Freshwater Ecosystems (undated) and CSIRO (2004). All captured fauna were released at the point of capture and all sample equipment was disinfected between sites.

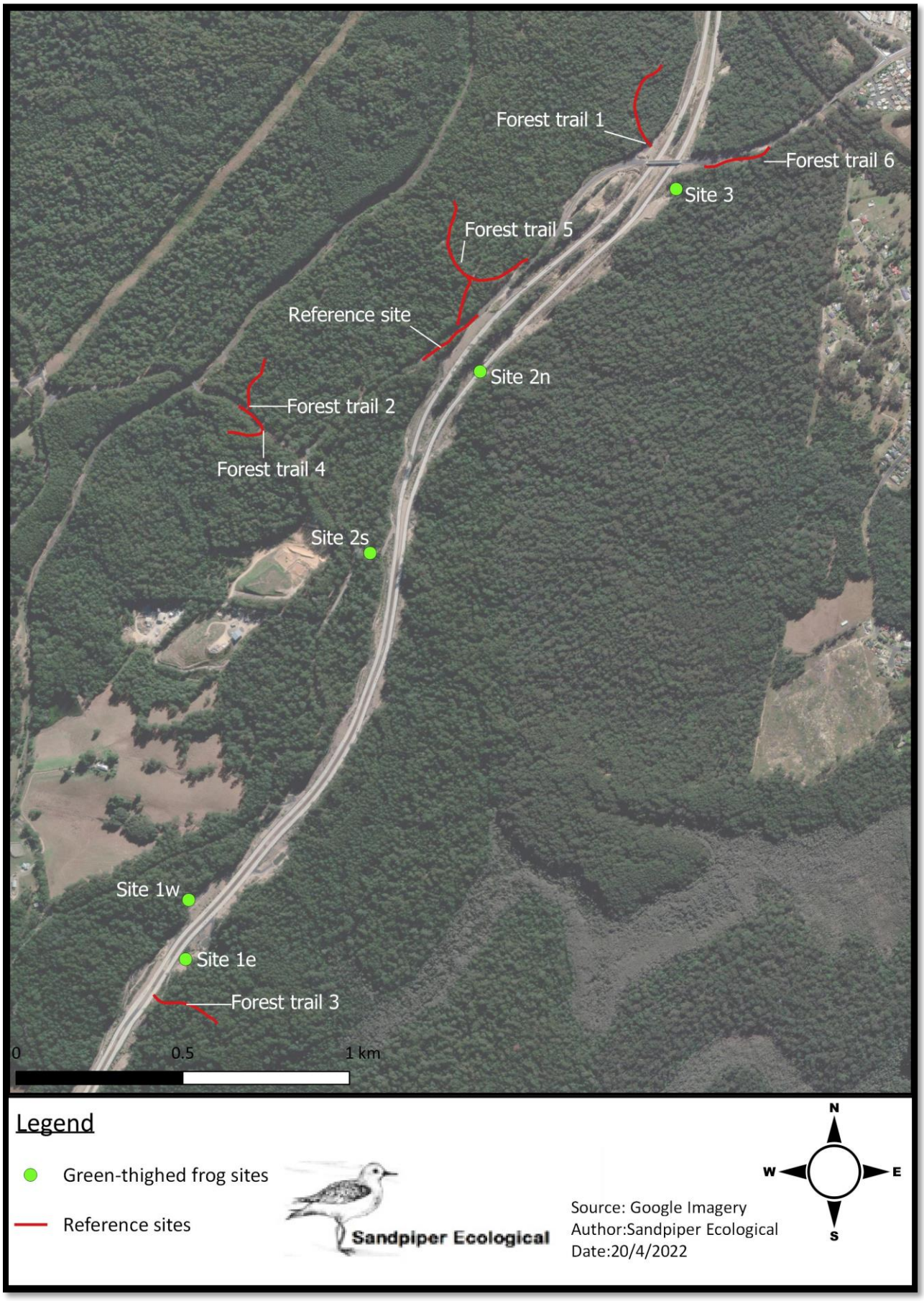

Figure 2: Location of reference site traverses in relation to green-thighed frog sample sites, WC2NH 2022.

3. Results

3.1 Weather conditions

Weather conditions were suitable for frog breeding (Table A1, Appendix A). Air temperature ranged from 21.7^{0}C to 21.9 ^{0}C and relative humidity 93 to 100%. Rainfall occurred during both survey periods. Intermittent heavy rainfall occurred during the first survey (24 February) while infrequent showers were present during the second survey (28 February). Low wind conditions and fair visibility occurred during both surveys.

3.2 Frog surveys

No green-thighed frogs were recorded during the field survey. Nine species of frog were recorded during both sample periods (Table 2). The highest species richness at a single site was six, recorded at site 1e (24 Feb), 2N (28 Feb) and 3 (24 and 28 Feb) (Table 2). The lowest species richness recorded was at the reference site where two species were recorded during each survey. Forest trail sites tended to have a lower species diversity with three species recorded over both sample periods including *Litoria gracilenta, Pseudophryne coriacea and Crinia signifera* (Table 3). The species recorded within the reference and forest trails sites were also recording within or around the breeding ponds

Crinia signifera and Limnodynastes peronii were the most widespread species, with each recorded at four of the monitoring sites (Table 2). *Litoria fallax, Pseudophryne coriacea* and *Adelotus brevis were* recorded at three monitoring sites each. Other frogs recorded within and around the breeding ponds included, *Lit. gracilenta*, *Lit.tyleri, Lit peronii and Uperoleia fusca* (Table 2).

Table 2: Frogs recorded during surveys of constructed breeding ponds adjoining the WC2NH upgrade.

Sample	Group	Species	Site 1E	Site 2N	Site 2S	Site 3	Reference site	Forest trails
Sample 1 (24 Feb)	Tree frogs	*Litoria fallax*	X			X	X	
		Litoria gracilenta	X	X				X
		Litoria tyleri	X			X		
		Litoria peronii				X		
	Burrowing frogs	*Crinia signifera*	X	X	X	X		
		Pseudophryne coriacea		X		X	X	X
		Adelotus brevis	X	X		X		
		Uperoleia fusca			X			
		Limnodynastes peronii	X	X	X	X		
		Total	**6**	**5**	**3**	**6**	**2**	**2**
Sample 2 (28 Feb)	Tree frogs	*Litoria fallax*	X	X		X		
		Litoria gracilenta		X				X
		Litoria tyleri	X			X		
		Litoria peronii						
	Burrowing frogs	*Crinia signifera*	X	X	X	X		X
		Pseudophryne coriacea		X	X	X	X	X
		Adelotus brevis	X	X		X		
		Uperoleia fusca			X			
		Limnodynastes peronii		X	X	X	X	
		Total	**4**	**6**	**4**	**6**	**2**	**3**

3.2 Tadpole survey

Six species of frog were recorded during tadpole surveys (Table 3), all of which were recorded during the previous frog survey. Sites 3 and 2S had the highest diversity with three and four species respectively (Table 3). Dytiscid larvae were recorded at sites 1E and 2N (Table 3).

Table 3: Results of tadpole survey conducted on 25 March 2022.

Group	Species	Site 1E	Site 2N	Site 2S	Site 3
Amphibians	*Litoria fallax*				X
	Litoria gracilenta		X	X	
	Litoria tyleri				X
	Crinia signifera	X	X	X	X
	Limnodynastes peronii			X	X
	Adelotus brevis	X			
Dytiscid larvae		X	X		
Fish		Nil	Nil	Nil	Nil

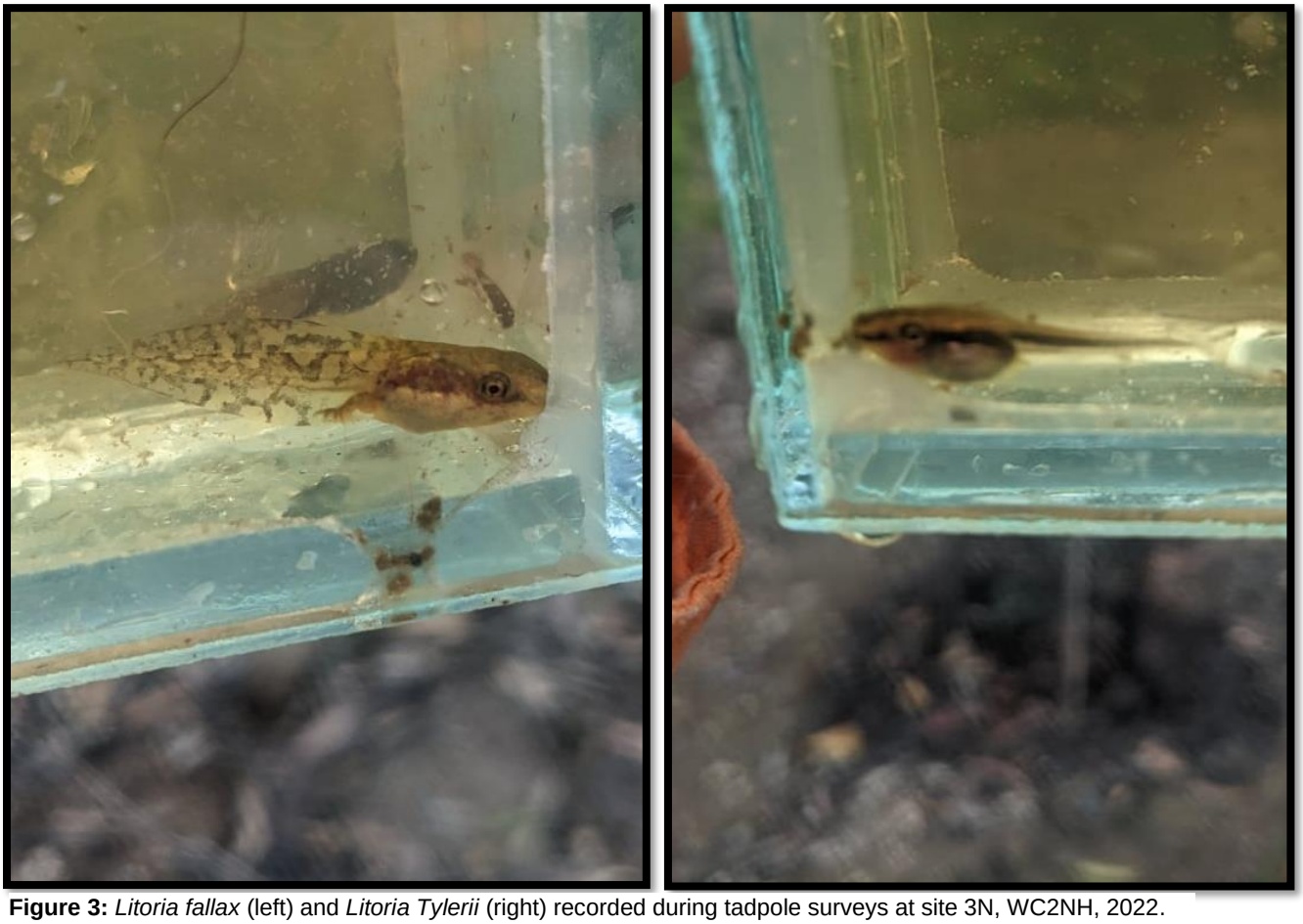

Figure 3: *Litoria fallax* (left) and *Litoria Tylerii* (right) recorded during tadpole surveys at site 3N, WC2NH, 2022.

Ponds were well vegetated at most sites during 2022 surveys (Table 4, Appendix A2). Perennial grass species were a dominant feature of many of ponds (Table 4). Stands of bulrush (*Typha orientalis*) were also recorded in three ponds, one at site 1E, 2S and 3 suggesting semi-permanent water. A picture of each pond, taken from the north side, is included in Appendix A.

Pond depth varied across all subject sites (Table 4). All constructed ponds contained water following a 30-day period between frog and tadpole surveys (Table 4). Water depth ranged from 20 to 320mm (Table 4).

Table 4: Water depth and notable features of each pond during year four operational monitoring, WC2NH, 2022.

Site	Pond Nº	Water Depth (mm)	Comment
1E	1	60	Fair condition, grassy
	2	100	Good condition, Typha present-semi permanent
	3	40	Fair condition, grassy
	4	160	Good condition, grassy
	5	20	Fair condition, grassy
2N	1	130	Good condition
	2	220	Good condition
	3	180	Good condition
	4	180	Good condition, grassy
	5	110	Good condition, grassy
2S	1	70	Good condition
	2	140	Good condition, grassy
	3	90	Good condition, grassy
	4	150	Good condition, grassy, Typha present-semi permanent
	5	50	Fair condition, grassy
3	1	130	Good condition, grassy Typha present-semi permanent
	2	190	Good condition, grassy
	3	180	Good condition, grassy
	4	320	Good condition, more open water
	5	220	Good condition, grassy

3.2.1 Fence condition

Frog exclusion fence was generally in good condition no fence defects were recorded during site traverses.

4. Discussion

4.1 Performance indicators

4.1.1 Continued presence of green-thighed frogs at breeding ponds or individuals calling from the edge of constructed ponds

No green-thighed frogs were recorded in the vicinity of breeding ponds, within the reference site or any forest trails during either field sample during 2022 monitoring. Potential breeding habitat did not develop in the remaining area of the reference site situated between the alignment and Old Coast Road in either sampling event. The expansion of reference site surveys to include habitat along forest trails to the west of Old Coast Road identified small areas of potential habitat, in the form of flooded wheel ruts and a flooded drainage line, yet no frogs were detected. Small areas of potential habitat (i.e. flooded depressions on a track) were also recorded along the ridge east of the reference site. The expanded reference site survey suggests there is limited potential breeding habitat in proximity to the alignment, which may explain the small number of individuals recorded during the baseline surveys. The study area certainly lacks the expansive areas of habitat typical of other breeding sites.

The breeding strategy of green-thighed frogs may mean they are more prone to the effect of drought than congeneric species that breed in permanent water bodies and/or breed after smaller volume rain events. The population in the study area may take several years to rebound following a severe drought, such as occurred in 2019. This is likely exacerbated by the small extent of breeding habitat in the study area and

the small baseline population. The non-quantitative nature of the baseline survey means it is difficult to make definitive statements on population size. The baseline surveys coincided with successive good quality breeding events that may have enabled frogs to expand their range. This is supported by summary of rainfall and breeding events (i.e. rain events of >75mm in 24hrs or 150mm in 72 hours) for the period 2008/2009 to 2019/2020 (Figure 3).

Rainfall data from the Bellwood weather station shows there has been a reduction in the number of annual breeding events since 2013/2014 (Figure 3). The baseline survey was conducted between January and March 2012 following the three highest years of rainfall recorded for the period 2008 to 2020 and years when there were 2-3 breeding events in the period October to March (Figure 3). In comparison, two of the three lowest rainfall totals between 2008 and 2020 have occurred since 2014/15 and four of the last five breeding seasons have had single breeding events only.

Variable breeding activity by green-thighed frog, even within a small geographic area, is not unusual (Lewis 2018) and variability may increase in cases where population size is small. Lewis (2013) recorded three male frogs at two sites during targeted surveys of the WC2NH alignment, which is low compared to other north coast breeding sites (Lewis 2018), although equivalent to the majority of sites sampled by Lemckert *et al.* (2006). The fact that baseline surveys occurred in January to March 2012, following successive wet years, means that frog abundance may have been elevated at the time of survey.

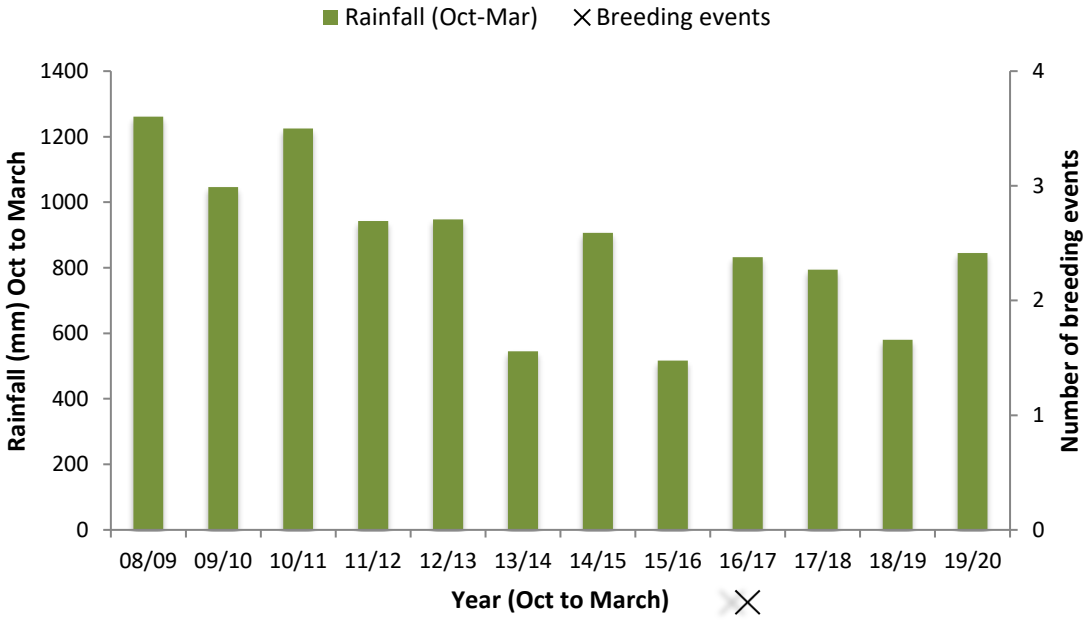

Figure 4: Cumulative rainfall totals recorded at the Bellwood weather station for each breeding year (i.e. October to March) from 2008 to 2020, and the number of breeding events (i.e. 75mm in 24hrs or 150mm in 72hrs) in each breeding year.

Expansion and contraction of green-thighed frog populations and local distribution is possible given the species breeding behaviour. That combined with modifications to habitat associated with the highway and local roadwork may explain the continued absence of frogs from the study area. Assuming lower abundance and restricted distribution due to climatic conditions it may take several successive breeding years before frog numbers increase sufficiently to warrant use of constructed ponds.

The likely small population, as shown by the baseline survey, and presence of breeding habitat elsewhere in Nambucca State Forest reduces the likelihood that frogs will readily encounter and utilise the subject ponds.

4.1.2 The presence of tadpoles, juveniles or metamorphs during follow up surveys

The absence of tadpoles, juveniles or metamorphs is likely due to the reasons discussed in the previous section and is consistent with the absence of adult frogs.

Overall pond condition has continued to improve over time with vegetation now established around all ponds and water present for a minimum of at least 30 days at all sites during 2022 surveys. Poor water retention was recorded in several ponds at sites 1E and 2S during 2021 surveys (Sandpiper Ecological 2021). In response to poor water retention, TfNSW applied bentonite to six ponds at sites 1E and 2S in August 2021 (Figure 4). Following bentonite application, water retention improved across all ponds at sites 1E and 2S during 2022 surveys. Water retention is also strongly influenced by climate and particularly follow-up rainfall between the initial breeding event and the tadpole survey. To some extent, the increased water retention volumes in the subject ponds may be attributed to the wet conditions experienced in March 2022 between the frog and follow-up tadpole surveys. Further monitoring is expected to see pond conditions continue to improve and be used to confirm whether ponds satisfy the optimal water retention period of 50 – 80 days suitable for green-thighed frog breeding.

Figure 5: Application of bentonite to pond 1 at site 2N during August 2021, WC2NH.

4.2 Corrective actions

Lewis (2013) listed five corrective actions:

1. Absence of green-thighed frogs from sites 1E, 2S, 2N and 3 - implement additional surveys of adjacent areas to confirm green-thighed frogs remain in that general area, and secondly, undertake a review and if deemed necessary, modify the ponds to improve any site suitability problems.

Sandpiper Ecological (2020) suggested that the need for additional surveys should be assessed following annual monitoring in year 3 of the operational phase. Additional surveys of adjacent areas during 2021 and 2022 suggest there is limited potential breeding habitat in proximity to the alignment, which may explain the small number of individuals recorded during the baseline surveys. The absence of frogs is not surprising given the low probability that a small number of frogs would find small breeding ponds situated in cleared, largely unsuitable, habitat. Uptake of constructed ponds, by green-thighed frogs, has been low even when ponds occur close to good quality breeding habitat. There is justifiable doubt about the viability and demand for constructed breeding ponds.

2. Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis - review and if deemed necessary, modify the ponds by placing a semi-permeable layer or further excavation.

All of the 21 ponds sampled during the tadpole survey contained water. Pond remediation work conducted at site 1E and 2N in autumn 2021 was successful with all ponds containing water during the 2022 tadpole surveys. No further remediation is recommended.

3. Ponds holding water for too long and representing unsuitable habitat (i.e., permanent versus ephemeral). The corrective action for this would be to improve drainage to ensure the ponds dries out.

***Typha orientalis* was present in three ponds, one at 1E, 2S and 3 during 2022, suggesting that some ponds may retain water for longer than the prescribed period. However, water retention depends not only on pond permeability but also on follow-up rainfall and local climatic conditions. Sandpiper suggests that corrective action is not warranted given the above average and consistent rainfall experienced during the 2021-2022 La Niña, contributing to the more permanent nature of the subject ponds.**

4. Exotic fish fauna recorded in breeding ponds. The corrective action for this would be to improve drainage to ensure the pond dries out.

Exotic fish were not recorded in any of the subject ponds.

5. Recommendations

Recommendations relating to the year four operational phase green-thighed frog monitoring program are summarised in Table 5.

Table 5: Recommendations following year four operational phase green-thigh frog monitoring and Transport for NSW response.

Number	Recommendation	Transport for NSW Response
1.	Continue annual monitoring of breeding ponds following suitable rainfall events. Searches for a suitable reference site should continue during the next monitoring event	Agree to be adopted

6. References

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Appendix A

Table A1: Weather conditions recorded during green-thighed frog surveys at WC2NH, 2022.

Sample	Temperature (^{0}C)	Relative humidity (%)	Cloud cover (%)	Rainfall (P/A)	Wind
24/02/2022	21.9	96	100	Intermittent heavy showers	RL
28/02/2022	21.7	93	100	Intermittent showers	NIL

Table A2: Constructed green-thighed frog pond condition progression from 2020-2022, WC2NH.

Site	Pond	2020	2021	2022
3	1			
3	2			

Site	Pond	2020	2021	2022
3	3			
3	4			

Site	Pond	2020	2021	2022
3	5			
1E	1			

Site	Pond	2020	2021	2022
1E	2			
1E	3			

Site	Pond	2020	2021	2022
1E	4			
1E	5			

Site	Pond	2020	2021	2022
2s	1			
2s	2			

Site	Pond	2020	2021	2022
2s	3			
2s	4			

Site	Pond	2020	2021	2022
2s	5			
2N	1			

Site	Pond	2020	2021	2022
2N	2			
2N	3			

Site	Pond	2020	2021	2022
2N	4			
2N	5