

# Frog Population Monitoring of Mulloon Creek

## Report on November 2022 surveys

Report prepared for The Mulloon Institute



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## **Executive Summary**

Frog monitoring surveys were undertaken at pre-determined sites along Mulloon Creek in November 2022. The surveys are being undertaken as part of a broader assessment of the biodiversity values of the Mulloon Creek catchment and assist with assessing the longer-term outcomes of the Natural Sequence Farming rehydration pilot project being undertaken at degraded sections of Mulloon Creek. These surveys represent a fourth season of annual monitoring of frogs along the creek that commenced initially in 2017 and were undertaken again in 2020 and 2021 (although the number of sites surveyed has changed marginally over each of these years, with this recent 2022 survey representing the highest number of sites included in the program since surveys commenced in 2017).

For this 2022 monitoring season, the surveys were conducted by a team of people using audio-recording techniques that were later analysed by an experienced herpetologist. A total of 61 stream sites and 8 farm dam/wetland sites were included in this 2022 season's surveys, and which occurred over a total of almost 20km of stream length between the upstream and downstream sites (with an additional approx. 6km of stream length of Sandhills Creek from the most upstream sites to the confluence with Mulloon/Reedy Creek).

The surveys found that the section of the Mulloon Creek catchment covered by this study continues to support a relatively healthy frog community along the creek as well as at select dams/wetland sites adjacent to the creek (but restricted to within the Mulloon Creek Home Farm property only), with a total of 9 frog species recorded during this 2022 study. This result represents a decrease in the total number of species recorded in the study area from the previous 2021 survey which recorded 11 frog species but remains an increase in the total number of species recorded in the study area from the earlier 2020 survey of 8 species, and the initial 2017 survey of 7 species.

The two species not recorded in this 2022 study but were recorded in the previous 2021 survey include Lesueur's Tree Frog and the Southern Leaf Green Tree Frog. The records of these species from 2021 were restricted to a very small number of sites in the upper reaches of Mulloon Creek within Landtasia where a rocky streambed substrate occurs. The records were also made by an experienced observer on the ground but were not detected in audio-recordings. For this 2022 season, only audio-recordings made by an inexperienced observer were relied on for those sites, and so the lack of records of these species may be attributable to observer experience rather than an actual lack of the species' occurrence within that section of Mulloon Creek. These two species, along with the Screaming Tree Frog, also represented new species records not previously recorded from the earlier 2020 and 2017 surveys. The Stiped Marsh Frog also was not recorded in the 2017 survey but has been detected in the subsequent three years of monitoring in 2020, 2021 and 2022.

Importantly, no species of frog had the lowest detection frequency rate this season compared with previous seasons (noting that the Lesueur's Tree Frog, the Southern Leaf Green Tree Frog and the Screaming Tree Frog had not been previously recorded at all during the 2017 and 2020 survey seasons). Some species however have had a number

of survey seasons collectively with low detection rates, but generally are/have been considered to be widespread and common species. These include notably Peron's Tree Frog (recorded at only 13% of sites) and the Striped Marsh Frog (recorded at only 11% of sites). These species, including Peron's Tree Frog especially, could potentially be suffering from a broader decline in abundance and distribution, which has been reported by other herpetologists. Further research may be required to confirm if there is in fact a real and significant decline in these species, and if so, what the cause of the declines may be attributable to.

The overall species richness of frogs at sites during the 2022 survey averaged 3.42 species/site, including an average of 3.26 species per stream site and 4.63 species per dam/wetland site. This represents a minor decrease in the species richness on the previous (2021) year's results of 3.8 species per site (including an average of 3.67 species per stream site and 4.75 species per dam/wetland site), but an increase in the species richness of the earlier (2020) year's results of 2.55 species per site (including an average of 2.44 species per stream site and 3 species per dam/wetland site), and relatively similar to the 2017 findings of 3.68 species per stream site (dam/wetland site surveys were not completed in the original 2017 study). It is noted however the 2017 recorded a maximum of only 6 species at a single site, and only 5 species in 2020, compared with a maximum of 7 species recorded at a single site in both this 2022 and the previous 2021 survey seasons. When looking at species richness per transect, a similar pattern emerges with an average of 4.623 species per transect this current 2022 season, slightly down on the number recorded for the 2021 season of 4.9 species per transect, but up on the earlier 2020 season of 3.56, but lower than the 2017 season result of 5 species per transect.

These results show that the frog community at Mulloon Creek appears to be relatively stable, with only minor fluctuations recorded in frog species richness over the four years of annual monitoring undertaken since 2017. The relatively small differences in species richness over the four years of surveys conducted may be attributable to a number of factors, including climatic conditions and timing of surveys, with this 2022 seasons' surveys being conducted notably earlier and during cooler conditions than the previous 2021 surveys. Observer skill may also have played a role as previously mentioned, particularly with the ability of an experienced observer to record more cryptic species, or species with lower abundance numbers, such as Lesueur's Tree Frog and the Southern Leaf Green Tree Frog, that are restricted in their occurrence (number of sites) and more difficult to detect via audio-recording and later/remote analysis techniques.

A number of both land management and further research recommendations have been made that are drawn out by the findings of this monitoring work and are described in detail in the full report.

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# 1 INTRODUCTION

## 1.1 Summary overview of project

This report provides a summary of the amphibian population surveys undertaken at Mulloon Creek near Bungendore NSW in November 2022.

The Mulloon Institute (TMI) has been working with landholders at a catchment scale to rehydrate the landscape and improve functionality and land use management along a section of Mulloon Creek near Bungendore, NSW. In 2006, the Mulloon Institute, with backing from the Southern Rivers Catchment Management Authority, and through the Mulloon Creek Natural Farms (MCNF) business, began a Natural Sequence Farming rehydration pilot project at degraded sections of Mulloon Creek. The work has included the installation of numerous weirs within the creek to reinstate more natural 'pool and riffle' sequences.

The primary aim of this work was to slow the movement of water through the creek to recharge the groundwater system within the floodplain. The targeted benefits of slowing the movement of water and recharging the groundwater was to reduce erosion and improve the productivity of the landscape, including the overall biodiversity values of the aquatic and terrestrial systems in the area.

Based on the success to date of the project at a property scale, a multi-faceted scientific research program to collect hydrological, soil, and biological data to assess the impact of the catchment scale approach, is being undertaken (Peel *et. al.*, 2022).

Part of the biodiversity surveys has included assessing the existing amphibian populations in the area to determine how they might respond to or benefit from the rehydration project. A preliminary survey was completed by Luke Peel in November 2017 with analysis and reporting by Frogwatch (Hofer 2017). Subsequent, follow-up surveys were completed in December 2020 (Patmore, 2021) and December 2021 (Patmore, 2022). The recent survey completed in November 2022 (and which is the focus of this report) was undertaken to increase the extent of baseline data on the existing frog community present within the defined study area of Mulloon Creek. For this survey, all of the previous years' sites were revisited including an additional transect (two sites) were added to the study that were not previously surveyed.

The data from these frog surveys will facilitate part of a broader project to monitor the effectiveness of the Mulloon Rehydration Initiative to regenerate the waterways and associated riparian corridor and floodplains over time.

The study area, survey methods including dates and timing of the surveys, as well as survey conditions, and results of the 2022 frog surveys are provided below.

## 1.2 Aims and objectives of this assessment

The broad aim of this project is to provide baseline data on the frog populations present within the defined sections of Mulloon Creek to allow for future comparisons of population numbers and assemblages to aid in the assessment of the benefits and

effectiveness of the rehydration project. Baseline data is an important tool to measure key conditions (indicators) and is commonly gathered before a project begins, to be used to monitor and evaluate a project's progress.

The key factors included in the baseline data collection are broadly in relation to the following:

- Habitat features and values including certain water variables and vegetation characteristics
- Frog species (and general estimates of abundance) present within the defined sections of Mulloon Creek in the study area.

The Frog surveys along Mulloon Creek will assist in identifying areas of high(er) diversity in frog species composition at sites which may also indicate the availability of high-quality habitat for various frog species. Identifying sites with higher quality habitat values will therefore assist in future decision-making, priority setting, planning and management of the area.

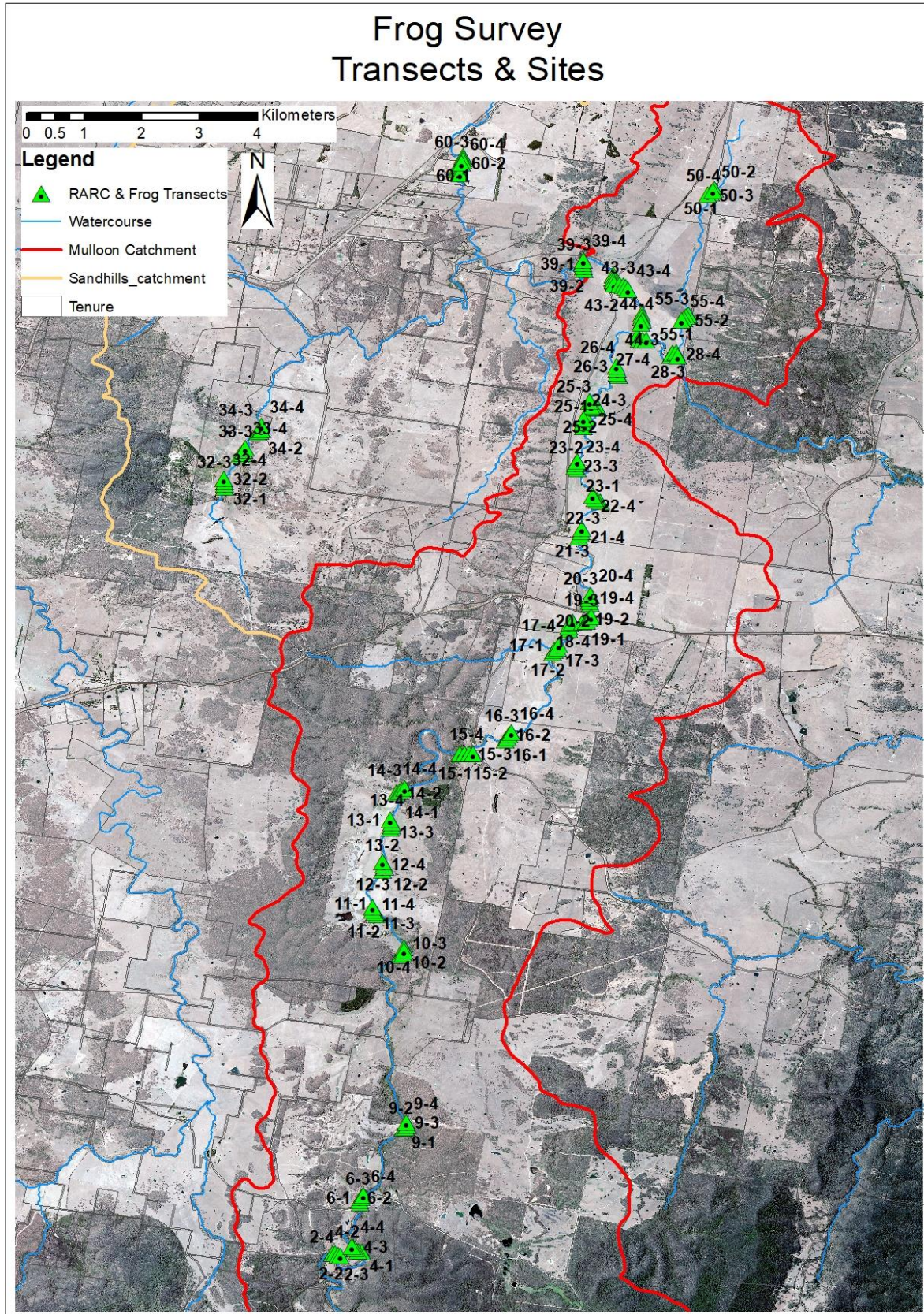
### **1.3 Study area - The Mulloon Creek**

The study area is situated along Mulloon Creek which is situated in the Southern Tablelands of New South Wales between Braidwood and Bungendore (Figure 1). This November 2022 study includes a total of 31 monitoring transects. The 31 transects are located between the Landtasia property in the southern/upstream parts of the Mulloon Creek catchment, approximately 5.5km due south of the MCNF Home Farm property and the Duralla – Sandhills properties, including sites on Sandhills Creek that confluence with Mulloon Creek to where it becomes Reedy Creek, as well as site in the far upper reaches of Sandhills Creek, about 3km north of the Kings Highway (see Figure 2 for the location of each site). This study area represents a total distance of almost 20km of stream length between the upstream and downstream sites (with an additional approx. 6km of stream length of Sandhills Creek from the most upstream sites to the confluence with Mulloon/Reedy Creek).



**Figure 1. Location of study area on the Mulloon Creek, Southern Tablelands, NSW**





**Figure 2. Study area – Mulloon Creek 2022 Frog Monitoring Transects**  
 (image courtesy the Mulloon Institute, 2021. Note: refer to results below for summary of which of the 31 out of the total of 60 shown RARC transects were included in this 2022 season survey)

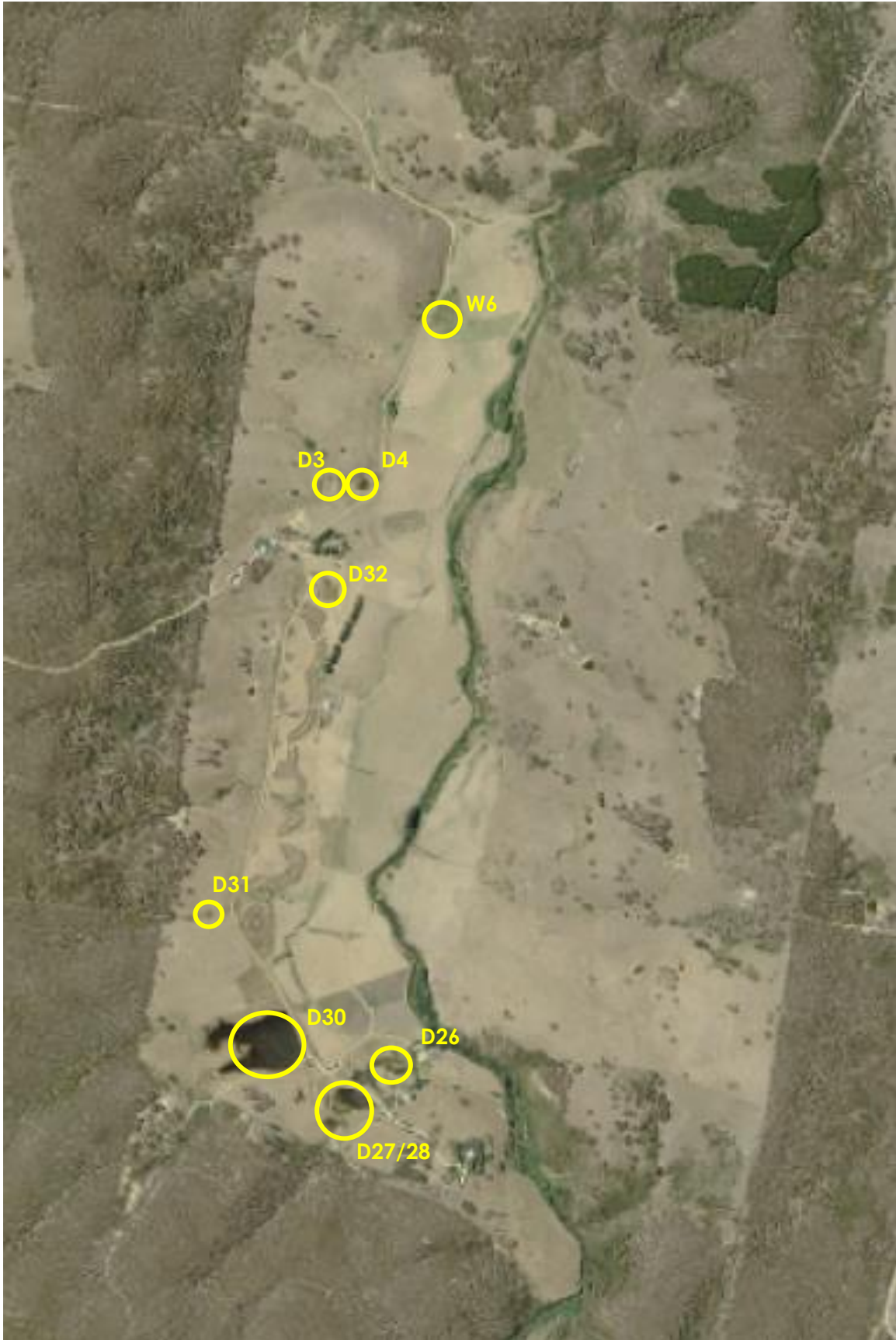


Figure 3. Location of (additional) farm dam/wetland monitoring sites at MCHF

## 2 Survey methods, effort, timing, and conditions

### 2.1 Survey methods and effort

A total of 62 survey sites were included in the November 2022 frog surveys along Mulloon Creek. The 62 survey sites were pre-established by TMI and involved 31 stream "transects" originally established for the RARC monitoring project (see Figure 2). Each RARC transect is approximately 200m long with the survey sites located at each end of the transect (i.e. 200m apart). Each transect is spaced approximately 1km (in stream length) apart. An additional eight (8) farm dam/wetland sites within the Mulloon Creek Home Farm property were also included in the survey program as described further below (see also Figure 3).

The 31 stream transects are located between the Landtasia property in the south of the catchment (starting at Transect No. 2) to the Sandhills Creek property in the northern parts of the catchment at the confluence of Mulloon and Reedy Creeks (Transect No. 44). This represents a total distance of more than 19km of stream length between the furthest upstream and downstream monitoring transects/sites. An additional five transects (32, 33, 34, as well as 60 and 61) are also included in the 31 monitoring transects. Transects 32 - 34 are located towards the upper reaches of Sandhills Creek, more than 4km southwest of the confluence of Sandhills Creek and Mulloon/Reedy Creek and transects 60 and 61 are located on Fairy Meadow Creek, approximately 4km to the northwest of the confluence of Sandhills Creek and Mulloon/Reedy Creek.

At each survey site, a combination of habitat and weather variables were collected as well as records of frog observations, including both direct audio/visual (if conducted by an experienced observer) and call recording (for later identification by an experienced herpetologist). For this survey, the habitat variables were collected separately during the daytime, and by a single observer (Luke Peel, TMI) to ensure consistency of visual estimates of habitat variables between sites. The weather variables were collected at the same time the frog surveys were being conducted.

During the daytime stream habitat survey, the observer recorded the water depth, pond level (as being on a scale between dry and full), water flow rate (on a scale of still to fast flowing), vertical water level drop (distance from top of bank to water level) and area of exposed soil (vertical distance from the High Water Mark (HWM) to the water's edge) was also recorded. Vegetation characteristics recorded at each site included the extent of emergent as well as fringe/edge vegetation, the extent of pond shaded by trees, evidence of mowing/slashing, as well as the width of the (unmown) buffer strip (if applicable).

For the frog surveys<sup>1</sup>, a timed (minimum) 5-minute observation period was undertaken at each site and involved primarily a call-based census of the frog species present. This included attempts at 'on-the-spot' identification of species, including estimating the total numbers of frogs calling, by the observers (depending on observer skill level; see

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<sup>1</sup> Note: only 61 nocturnal frog audio surveys were successfully completed (at 31 of the RARC transects). A single site T\_44\_4 had a corrupted audio file.

below). The air and water (where possible) temperature, sky (i.e. cloud cover) and wind conditions were also recorded at each frog survey site/occasion.

Given the large number of sites and area covered by the survey and the requirement to complete the surveys in a short period of time (on the same night), it was necessary to bring in help to complete the work. For this survey, a number of TMI staff and volunteers were enlisted, some of whom had little experience in frog (call) species identification. For this reason, the use of (minimum 5-minute) audio file recording was employed. The call files were subsequently assessed, and the frog species recorded by an experienced herpetologist (Sam Patmore). It is acknowledged that whilst not all frogs may have been captured during each audio recording, given the large total number of recordings made along the same stream and generally within close proximity and timing of each other (i.e. <200m apart for sites on the same transect and less than 1km (generally) for sites between transects), it is expected that a sufficiently comprehensive assessment of the overall amphibian community along Mulloon Creek was completed.

In addition to the (62) stream sites, additional frog and habitat surveys were undertaken at eight (8) of the 'farm dam' sites within MCHF (which includes a "wetland" site located in the lower floodplain valley floor – "Wetland 6"; see Figure 3).

The procedures described above are the same as for the previous 2020 and 2021 surveys and which generally follow the ACT Frogwatch protocol. They are therefore very similar in manner to the 2017 survey (Hoefler 2017) (except for the increased overall survey area and effort, being extended call recording period). This repetition of methodology therefore allows for good comparison between the findings of this survey season and the previous 2017, 2020 and 2021 seasons' survey findings.

## **2.2 Survey timing and conditions**

The surveys (both habitat and frog surveys) were completed on the 9<sup>th</sup> of November 2022. Generally, the habitat variables were collected during the daytime to facilitate observations of vegetation condition and stream flow features, although in some circumstances, due to timing constraints, some of the habitat assessments were conducted at night at the same time as the frog surveys. All of the frog surveys were completed at night, with surveys commencing no earlier than 20.30 hours once it was sufficiently dark and most frog species had become active/started calling.

The weather conditions for the surveys were generally suitable for frog surveys. The air temperature on the evening of 9/11/22 was mild, ranging from about 16°C at the start of the survey (8.30pm) and dropping to about 12°C at the end of the survey (almost 12am in some circumstances). The sky conditions were recorded mostly as being (partly) cloudy to overcast. Wind was mostly recorded as being still to occasionally a light breeze. This temperate range was a little cool for Spring, but still regarded as being sufficiently warm to encourage good frog activity (calling) levels to ensure an adequate census of frog species was achieved on the night.

Water temperature was measured/recorded at some of the sites but was also supplemented by stream gauge data at a number of locations along Mulloon Creek (including at Landtasia in the upper reaches, as well as at 'Mid-Mulloon', 'Lower-Mulloon' and Reedy Creek). During this survey, recorded water temperatures ranged

from between about 15 to 18 degrees Celsius (from upper reaches to lower reaches respectively, but also dropping on average about 1-1.5°C over the course of the survey from 20.30 to 23.30). This (moderately) warm water temperature would also have been suitable for ensuring sufficient frog activity levels to accommodate an acceptable survey program.

It is also noted that there was extensive rainfall in the late-Spring period leading up to this with some periods of high rainfalls for the second half of October and first half of November 2022. Specifically, for the Bungendore region, a total of 139mm of rain fell throughout October 2022 and a further 72mm in the first 8 days of November 2022, including 22mm of rain the day before the surveys on 8/11/2022. This level of rainfall is substantially higher than the mean monthly rainfall in the region for October (of approx. 57mm) and also for November (of 82mm for the entire month). This high level of rainfall further added to the suitable timing of the surveys with lots of water present in the system including both the creek and adjacent waterbodies (farm dams and wetlands).

**Table 1. Timing and conditions for the 9<sup>th</sup> November 2022 Mulloon Ck frog surveys**

Stream Site No.	Survey Time	Air Temp (°C)	Water Temp (°C) <sup>^</sup>	Sky (1 to 6)	Wind (1 to 4)
<b>Mulloon RARC Sites</b>					
T_2_1	20.47	NR	16.5	3	1
T_2_4	21.01	NR	16.5	3	1
T_4_1	21.30	NR	16	3	1
T_4_4	21.46	NR	16	3	1
T_6_1	22.10	NR	15.5	2	3
T_6_4	22.32	NR	15.5	2	3
T_10_1	20.25	16	17	3	1
T_10_4	20.35	16	17	3	1
T_11_1	22.00	12.6	16.5	2	1
T_11_4	21.54	12.7	16.5	2	1
T_12_1	21.10	15	17	2	1
T_12_4	20.50	15	17	2	2
T_13_1	23.34	11.3	16.5	2	1
T_13_4	23.12	11.8	16.5	2	1
T_14_1	22.52	12.1	16.5	2	1
T_14_4	22.30	12.6	16.5	2	1
T_15_1	23.12	12	16.5	1	1
T_15_4	23.21	12	16.5	1	1
T_16_1	22.53	12	16.5	1	1
T_16_4	22.41	12	16.5	1	1
T_17_1	22.12	12	16.5	1	1
T_17_4	21.57	12	17	1	1
T_18_1	20.51	13.5	17	1	1
T_18_4	20.40	14	17	1	1
T_19_1	20.35	14	17	1	1
T_19_4	20.30	14	17	1	1
T_20_1	21.28	13	16.5	1	2
T_20_4	21.42	12	16.5	1	3
T_21_1	20.23	14.5	17.5	1	2
T_21_4	20.48	14	17.5	1	1
T_22_1	21.17	13	17	1	2
T_22_4	21.27	13	17	2	3

T_23_1	21.55	13	17	2	2
T_23_4	22.25	12.5	17	2	1
T_24_1	22.40	12	17	2	1
T_24_4	22.50	12	17	2	1
T_25_1	21.00	13	17.5	1	1
T_25_4	21.10	13	17.5	1	1
T_26_1	22.15	12.5	17	1	2
T_26_4	22.10	12.5	17	2	2
T_27_1	22.55	12	17	1	2
T_27_4	NR	NR	NR	NR	NR
T_28_1	23.20	11.5	17	1	2
T_28_4	NR	NR	NR	NR	NR
T_32_1	20.53	18	21	1	2
T_32_4	21.06	NR	19	1	1
T_33_1	21.34	13	19	NR	NR
T_33_4	NR	12	19	2	3
T_34_1	22.23	12	22	1	2
T_34_4	22.40	13	21	NR	NR
T_39_1	21.20	15	18	1	NR
T_39_4	21.38	15	18	2	3
T_42_1	21.55	14	17	2	2
T_42_4	22.05	14	17	2	2
T_43_1	22.20	13	16	1	2
T_43_4	22.30	12	16	1	2
T_44_1	22.50	13	17	1	2
T_44_4	23.05	10	17	1	2
T_60_1	20.30	14	17.5	1	3
T_60_4	20.50	14	17.5	1	3
T_61_1	21.00	14	17.5	1	3
T_61_4	21.10	14	17.5	1	3
<b>MCHF Dam/Wetland Sites</b>					
D3	22.10	14.5	19.5	2	2
D4	22.00	14.5	19.5	2	2
W6	22.15	14	18.5	2	2
D26	21.00	16	19.5	2	2
D27/28	21.15	16	19.5	2	2
D30	21.30	15.5	19	2	2
D31	21.40	15.5	19	2	2
D32	21.50	15	19.5	2	2

NR= not recorded

^For many sites, water temperature was extrapolated from stream gauge data as opposed to direct measurement at each site

## 3 RESULTS

### 3.1 Habitat Assessments

#### 3.1.1 Stream Transect Sites

The results of the habitat assessments completed for the 62 stream (only) monitoring sites are described below, including a brief comparison with previous seasons' (2020 and 2021) results (note that habitat assessment data was not provided for the 2017 survey findings, and therefore comparisons cannot be made for that year).

The full results of the habitat descriptions and water quality measurements are provided at Appendix B and separately as a Microsoft Excel spread sheet.

#### Water levels and stream banks

Generally, water depth category estimates at most sites were recorded as '>30cm' (n=56/62 sites), with only six sites recorded as '<30cm' (and no sites recorded as 'unknown' or 'dry'; see Figure 4). This is a very similar result to last (2021) season's results where water depth levels at most sites (52/60) were also recorded as being '>30cm'. This result is also not dissimilar to the results of the earlier 2020 survey in which 28/36 sites were also recorded as being '>30cm' and only four sites recorded as <30 cm.

The 'Pond' (or stream) levels however were recorded mostly as being 'bank very exposed' (n=49/62 sites), with the remaining 13/62 sites all recorded as 'nearly full'. No sites were recorded as 'full', 'nearly dry' or 'dry' (see Figure 5). This result is in contrast to last (2021) season's results where 55/60 sites recorded as being 'nearly full', and somewhat dissimilar to the 2020 survey in which 15/36 sites were recorded as 'nearly full' and the remaining 21/36 sites recorded as 'bank very exposed'.

Water flow rate was recorded at most sites as 'moderate' (n=51/62), with eight sites recorded as 'slow' and three sites recorded as 'fast' (see Figure 6). This contrasts again with last (2021) season's results where 22/60 sites were recorded as having 'moderate' flow rates and 36/60 sites recorded as 'slow' flow rates as well as the previous (2020) season's results where 9/36 sites recorded as having 'moderate' flow rates and 26/36 sites were recorded as having 'slow' flow rates. These flow rate results suggest that there was at least as much if not more water moving through the system than in previous years.

Overall, these results indicate that water levels in the system were moderate to high and at least as much water in the system as the previous two years' monitoring, if note more<sup>2</sup>. Some observer bias may have occurred as the high proportion of sites recorded as having 'bank very exposed' this season seems at odds with the previous years' results as well as in comparison to recorded water depths and flow rates this season which both indicate substantial water in the system. The noted high levels of rainfall in the weeks preceding the surveys also would suggest that there was relatively high water levels.

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<sup>2</sup> A cursory review of the water levels from stream gauge data on Mulloon Ck from 2016 to August 2022 (provided by TMI) indicates that stream levels and water flows were generally higher on average in mid-2022 leading up to the November 2022 survey period than in previous years.

Accordingly, the exposed banks may be a feature related more to vegetation conditions along stream banks (discussed further below) as opposed to a measure of water level/inundation.

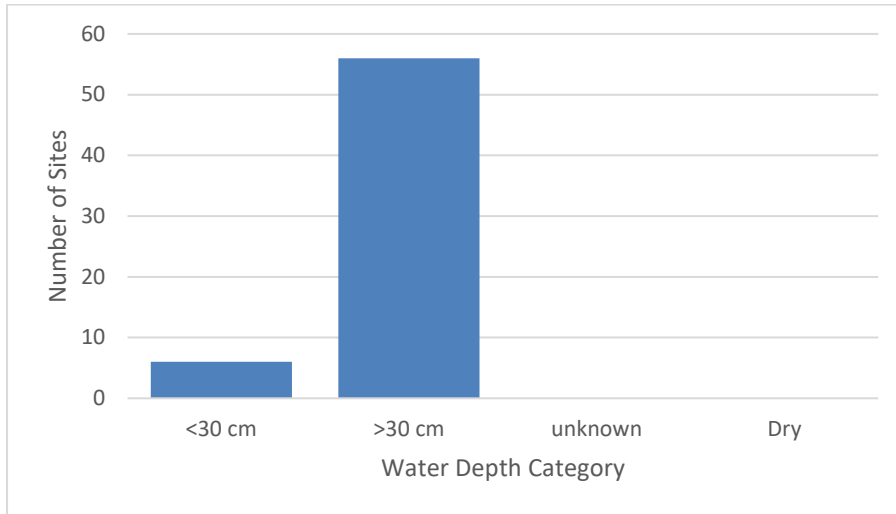


Figure 4. Water depth estimates at sites during the 2022 frog surveys.

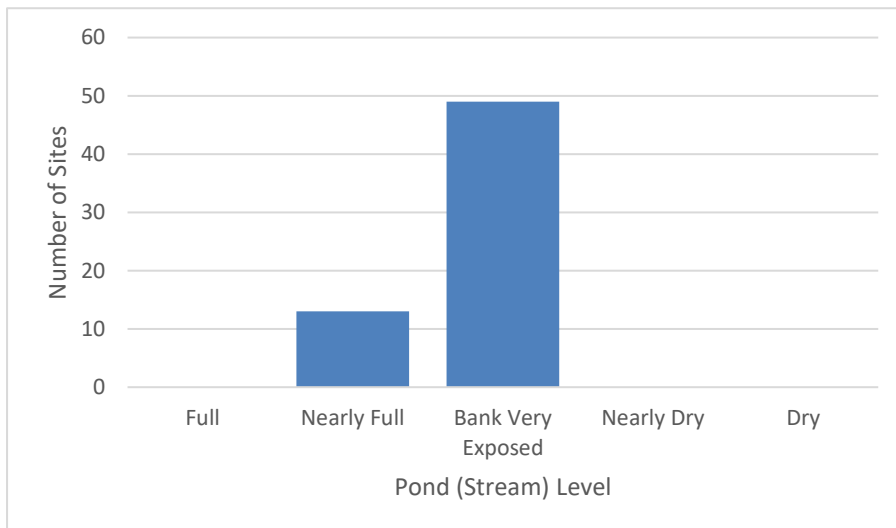


Figure 5. Pond (stream) level estimates at sites during the 2022 frog surveys.

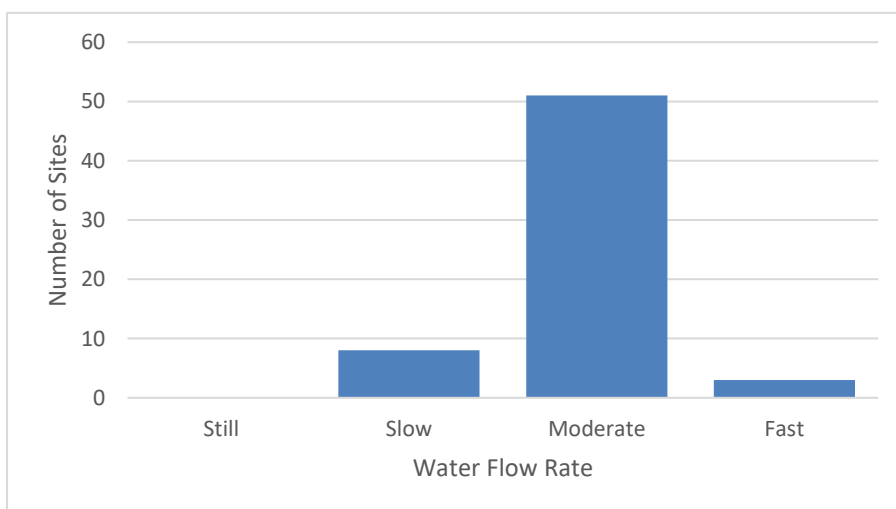


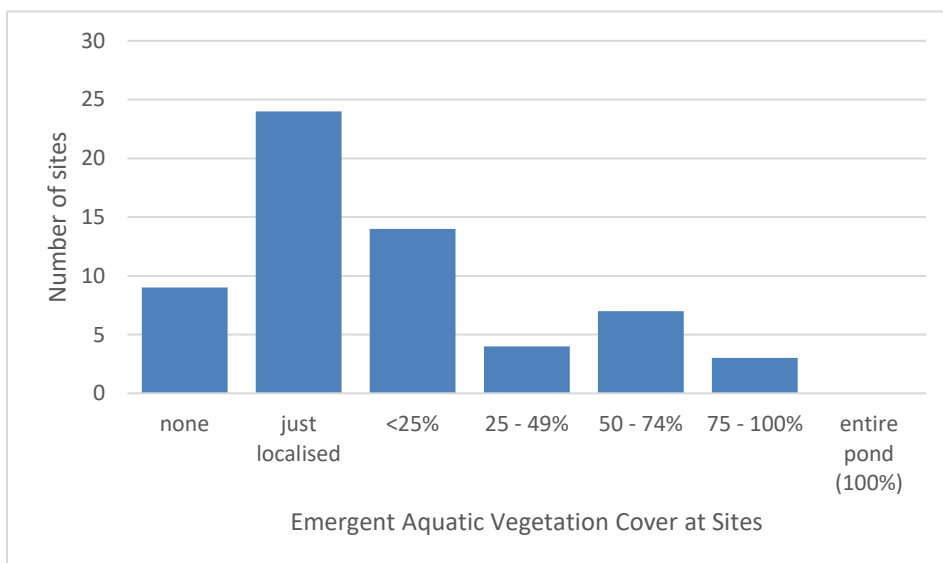
Figure 6. Water flow rate estimates at sites during the 2022 frog surveys.



The estimated vertical water level drop across the 62 stream sites ranged from a minimum of 0.5m to a maximum of 3m (recorded at both sites on Transect T\_61), with an average drop across sites of 1.46m. This compares markedly with the 2021 estimates of vertical water level drop which ranged from 0.0 to 0.5m with an average drop across (n=60) sites of 0.32m, and with the initial 2020 estimates which recorded a range of 0.25 to 10m (at an average of 2.4m) for vertical water drop. It is considered unlikely that this variable would have actually changed that much over this timeframe and therefore, the differences are more likely a result of observer bias/inconsistency in visual estimates (including likely a different approach/method for estimating values). Of note, during the 2020 survey season, the habitat assessments were conducted by a number of different people/observers while for the 2021 and 2022 survey seasons, all of the habitat assessments were conducted by the same (single) observer.

Vegetation

*Emergent aquatic vegetation cover* (recorded at 61/62 sites) at ponds varied markedly across sites with a relatively broad spread of scores across the various cover range categories, although no sites recorded a score of 100% or ‘entire pond’ cover of emergent vegetation (see Figure 7). Most sites (24/61) recorded a cover value of “just localised” with 14 sites recording a cover of between ‘just localised’ and <25%, four sites recording a cover of between 25–49%, seven sites recording a cover value of between 50–74%, three sites recording a cover value of between 75–99% and nine sites recording no emergent vegetation cover.



**Figure 7. Emergent Vegetation Cover at sites during the 2022 frog surveys.**

These emergent vegetation cover results are not notably dissimilar with last (2021) season’s results where the majority (31/59 sites) recorded a cover value of “just localised”, followed by a relatively even number/spread of score in the other range categories. Notably, only two sites last season recorded no emergent vegetation cover. For the earlier 2020 season, all but one (35/36, or 97%) of the sites had a cover value of less than 50% (with most, 77% of sites, recording either “just localised” or <25% cover values).

These results indicate that on the whole across the entire system, emergent vegetation cover values appear to have increased marginally over the past two seasons given a greater number of sites with recorded cover values of greater than 50% (10/61 for 2022 and 11/59 for 2021, compared with 1/36 for 2020). Several consecutive years of good rainfall and relatively high stream levels may have contributed to this increase, although again with other variables, observer bias/inconsistency may also be playing a part.

Fringe or edge vegetation cover (recorded at 60/62 sites; see Figure 8) also varied greatly across sites, although it was noted that all sites recorded a cover score of at least 25% (i.e. no sites recorded a cover value of 'none'). Overall, the fringe/edge vegetation cover scores were relatively high with the highest number of sites (18) recording a cover score of between 75–99%, 16 sites recording cover of between 50–74%, 15 sites recording cover of between 25–49%, and only six sites recording a cover of either <10% or 'just localised' (three sites each).

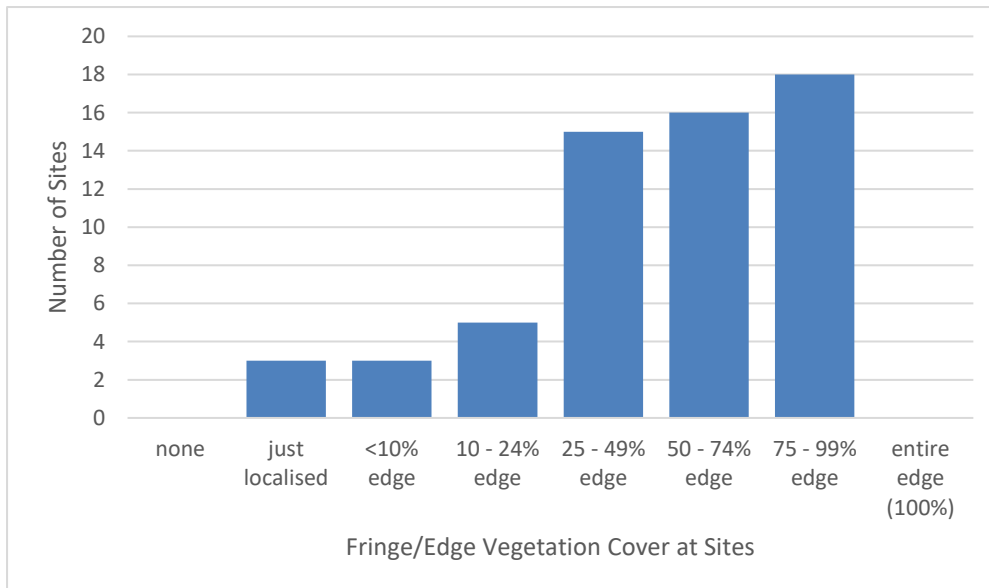


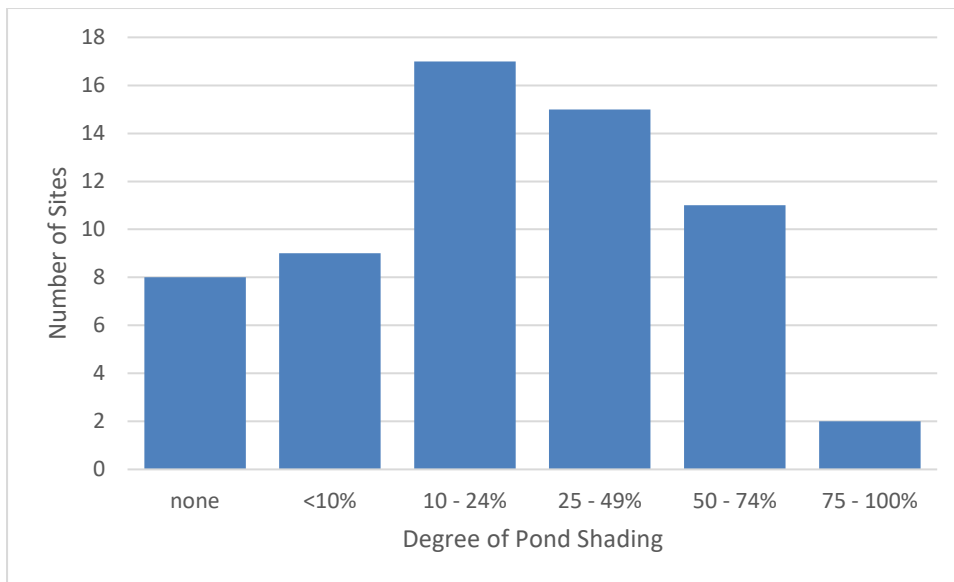
Figure 8. Fringe/Edge Vegetation Cover at sites during the 2022 frog surveys.

Compared to previous seasons' results, it is noted that when looking at broader fringe/edge vegetation cover categories (combined), for this current (2022) season, 34/61 (56%) sites had cover levels of 50% or higher, whereas last (2021) season's results had 50/58 (86%) of sites surveyed with cover levels of more than 50% while the earlier (2020) season had 27/36 (75%) sites with cover levels of more than 50%. Also of note is that for the current (2022) season, 13/61 sites (21%) had fringe/edge vegetation cover levels of less than 25% whereas no (0%) sites had cover levels of less than 25% for the 2021 season and 2/36 (6%) of sites had cover levels of less than 25% for the earlier 2020 survey season. Additionally, no (0%) sites recorded a cover score of 'entire edge' (or 100% cover) for this current season, which was the same result for the earlier 2020 season, whereas 13/58 (22%) of sites surveyed during the 2021 season had cover levels of the "entire edge".

Given the above, an apparent reduction in the overall levels of fringe/edge vegetation cover is shown in these comparisons of results between years. This drop could, as with

other variables, at least partly be a consequence of observer bias/inconsistency, although in this instance it would appear that at least some actual change in cover values has occurred for fringe/edge vegetation. A potential explanation for this change could be a function of higher stream levels and velocities as previously mentioned (and indicated by a cursory review of stream gauge data from 2016 to August 2022, leading up to the current survey). The dynamics of the apparent increased water levels (and flows) that occurred over the previous years and specifically in 2022 leading up to the November 2022 survey period could have affected aquatic and fringe vegetation cover levels through more regular/increased battering of this vegetation by almost consistent high water levels and increased water flow pulses.

Levels of pond shading (recorded at 62/62 sites) also varied greatly across sites (Figure 9). Eight sites recorded no shading at all of the pond, while nine sites recorded a shade cover score of 1-9%, 17 sites recorded shade cover of between 10-24%, 15 sites recorded shade cover of between 25-49%, 11 sites recorded shade cover of between 50-74%, and only two sites (T\_20\_1 & T\_39\_4) recorded shade cover of 75-100% of the pond.



**Figure 9. Level of Pond Shading at sites during the 2022 frog surveys.**

Compared with last year's 2021 season results, the levels of pond shading (recorded at 60/60 sites) also varied greatly across sites, but were generally higher than the current (2022) season. For the current season a combined 13/62 (21%) sites recorded a shade score of 50% or higher compared to 32/60 (53%) sites for the 2021 season and 8/36 (22%) sites for the earlier 2020 season. Again, as with other variables, observer bias/inconsistency could be playing a factor (at least partly) in these results as shade cover is not expected to change markedly on a year-on-year basis, and noting the similar results between 2020 and 2022, with the intervening 2021 season appearing the standout.

There was no recorded evidence of mowing or slashing within close proximity (5m) of the creek at any of the 62 stream sites and a minimum 5m buffer was also recorded at all 62 sites. This is the same result as the previous (2021) season (for all 60 sites) and

comparable to the earlier 2020 season where 33/36 of the sites recorded no evidence of mowing and a minimum 5m buffer was present.

### **3.1.2 Dam/Wetland Sites**

Water levels within the eight dam/wetlands included in this study were all relatively high with all sites recorded as "Full" and all sites recording a water depth of more than 30cm. Additionally, all sites had a vertical water level drop of 20cm or less and a maximum area of exposed soil of 0.5m or less. This was the exact same result for last season's (2021) survey findings (note that habitat assessments were not completed for the previous (2020) season's survey and so no comparisons are made against that year's results).

For emergent aquatic vegetation cover, most sites (6/8) recorded 'just localised' emergent aquatic vegetation cover scores, with one site (D4) recording a score of between 'just localised and <25%', and one site (W6) recording an emergent aquatic vegetation score of 'entire pond'. This is a shallow artificially constructed wetland and is dominated by dense thickets of Typha and Phragmites. This is a relatively similar finding to last season's (2021) survey findings where 7/8 sites recorded 'just localised' emergent aquatic vegetation cover and site W6 also recording a cover score of 'entire pond' (with site D4 increasing cover marginally from 'just localised' in 2021 to <25% in 2022).

For fringing/edge vegetation, two sites (D30 & D31) recorded a score value of 25-49%, three sites (D4, D27 & D32) recorded a score value of 50-74% and three sites (D3, W6 & D26) recorded a value of 75-99%. This contrasts marginally with last season's (2021) survey findings where only one site (W6) recorded a value of 75-99%, 5/8 sites had 50-74% cover and 2/8 sites had 25-49% cover; indicating only two sites (D3 & D26) changed/increased their score from 2021 to 2022. Overall, these results indicate there is relatively good cover of fringing vegetation across most sites.

Levels of pond shading across the dam and wetland sites varied with three sites (D3, D4 and D32) recorded as having no shading of the pond, four sites (W6, D27, D30 & D31) recorded as having 1-9% shade and one site (D26) having between 10-24% shading of the pond. These are similar findings with last season's (2021) survey where (4/8 sites) had no shade, 3/8 sites had 1-9% shade and one site had 10-24% shading of pond.

There was evidence of mowing around 3/8 sites (D26, D27 & D30), as well as some evidence of some stock access and grazing of surrounding vegetation at many of the sites. Two sites (D3 & W6) had a >5m vegetation buffer, while the remaining 6/8 sites had a vegetation buffer of between 1-5m.

The full results of the habitat descriptions and water quality measurements are provided at Appendix B and separately as a Microsoft Excel spread sheet.

### 3.2 Frog species detected during the December 2021 Surveys

The results of the frog surveys for the 61 successfully completed (out of 62 RARC) stream and 8 dam/wetland monitoring sites are described below. In summary, a total of nine (9) species were detected across the total combined 69 monitoring sites during the November 2022 survey (Table 2). This included the following species:

- *Crinia signifera*, Common Eastern Froglet
- *Crinia parinsignifera*, Plains Froglet
- *Limnodynastes dumerelli*, Eastern Banjo Frog
- *Limnodynastes peronii*, Striped Marsh Frog
- *Limnodynastes tasmaniensis*, Spotted Grass Frog
- *Litoria peronii*, Peron's Treefrog
- *Litoria quiritatus*, Screaming Tree Frog
- *Litoria verreauxii*, Whistling Treefrog
- *Uperoleia laevigata*, Smooth Toadlet

Table 2 below shows the number/frequency of sites that each species was detected at (and includes the both the 61 stream sites and 8 dam/wetland sites; therefore, the total number of sites each species was recorded at and the detection frequency is out of 69 completed frog survey monitoring sites; results are also provided for the stream and dam/wetland sites separately).

**Table 2. Species recorded and detection rates during the November 2022 Mulloon Ck frog surveys**

Species Name	Common Name	Number of sites recorded at (n=69)	Detection Frequency (% of sites detected at)
<i>Crinia parinsignifera</i>	Plains Froglet	40 (32/61 & 8/8)	58% (52% & 100%)
<i>Crinia signifera</i>	Common Eastern Froglet	62 (54/61 & 8/8)	90% (89% & 100%)
<i>Limnodynastes dumerillii</i>	Eastern Banjo Frog	37 (34/61 & 3/8)	54% (56% & 38%)
<i>Limnodynastes peronii</i>	Striped Marsh Frog	8 (7/61 & 1/8)	12% (11% & 13%)
<i>Limnodynastes tasmaniensis</i>	Spotted Grass Frog	43 (36/61 & 7/8)	62% (59% & 88%)
<i>Litoria peronii</i>	Peron's Tree Frog	11 (8/61 & 3/8)	16% (13% & 38%)
<i>Litoria quiritatus</i>	Screaming Tree Frog	2 (2/61 & 0/8)	3% (3% & 0%)
<i>Litoria verreauxii</i>	Whistling Tree Frog	21 (17/61 & 4/8)	30% (28% & 50%)
<i>Uperoleia laevigata</i>	Smooth Toadlet	11 (8/61 & 3/8)	16% (13% & 38%)

No species was detected at every single site in this survey. The Common Eastern Froglet was the most frequently detected species during the surveys, being detected at 62 of the 69 (or 90%) sites surveyed in total (including at 54/61, or 89%, of the creek sites). This species is common and widespread across much of eastern Australia. Other species recorded regularly (i.e. at more than 50% of the surveys sites) included the Plains Froglet (40/69 sites), the Eastern Banjo Frog (37/69 sites) and the Spotted Grass Frog (43/69 sites).

Table 3 below shows the detection frequency of species across the four survey seasons and for stream sites only. The detection frequency, being the percentage of sites that a

species was recorded at, provides a basic surrogate measure of the overall extent of distribution of each species across the study area.

**Table 3. Comparison of detection frequency of species between survey seasons (stream sites only).**

Common Name	2017 survey detection frequency	2020 survey detection frequency	2021 survey detection frequency	2022 survey detection frequency
Plains Froglet	62%	<u>47%</u>	<b>64%</b>	52%
Common Eastern Froglet	<b>94%</b>	<u>75%</u>	84%	89%
Eastern Banjo Frog	42%	<u>14%</u>	48%	<b>56%</b>
Striped Marsh Frog	<u>0%</u>	<b>28%</b>	26%	11%
Spotted Grass Frog	<u>16%</u>	19%	<b>67%</b>	59%
Lesueur's Tree Frog	0%	0%	<b>3%</b>	0%
Southern Leaf Green Tree Frog	0%	0%	<b>2%</b>	0%
Peron's Tree Frog	<b>50%</b>	31%	<u>5%</u>	13%
Screaming Tree Frog	0%	0%	<b>40%</b>	3%
Whistling Tree Frog	<b>100%</b>	31%	<u>10%</u>	28%
Smooth Toadlet	11%	<u>0%</u>	<b>14%</b>	13%

\*Bold text represents year with highest recorded detection frequency; underlined text represents year with the lowest recorded detection frequency

In comparison with previous years' results for the stream site surveys, it is noted that every species detected during the previous 2017 and 2020 surveys was successfully detected during the 2022 survey, with an increase of two species on the 2017 survey (Striped Marsh Frog and Screaming Tree Frog), and an increase of one species on the 2020 survey (Screaming Tree Frog).

However, in comparison with the 2021 survey, two species recorded during last season's survey were not recorded during the current 2022 survey. This included Lesueur's Tree Frog (*Litoria lesueuri*) and the Southern Leaf Green Tree Frog (*Litoria nudidigitus*).

These two species were recorded at sites located on upper reaches of Mulloon Creek within Landtasia, with Lesueur's Tree Frog recorded at sites T\_2\_4 and T\_4\_4 and the Southern Leaf Green Tree Frog recorded at site T\_6\_4. As noted in the final report for last season's 2021 survey, these sites were not surveyed in 2017 or 2020 and therefore, they do not represent records of a new species for the parts of study area where repeated surveys have already occurred. It is also noted that both of these species were recorded directly by an experienced observer at that time on-site and not by audio recording.

For this season's survey, an inexperienced observer conducted the audio-recording at the sites on Transects 2, 4 and 6 and so did not make any direct records of frogs on the data sheet during the survey period. Additionally, the audio recording at many of these sites were difficult to later interpret as the creek is quite noisy in this section and

prominent in the recording. Consequently, hearing and identification of calling frogs was very difficult at these sites (only one species was positively/confidently detected by audio at both sites on Transect 2, and two species, three combined for the two sites on Transect 4. Transect 6 yielded more species, but the audio identification was still difficult over the noisy stream). This could potentially account for the lack of records of the two species rather than any conclusion that these species are not (no longer) present at those sites.

Other notable observations in comparing the 2022 survey season results with the previous years' results on the detection frequency for each species include the following:

- The 2022 survey saw the highest detection frequency rate for only one species, the Banjo Frog
- The 2022 survey did not record the lowest detection rate for any species over the four years of surveys completed (noting the lack of observations in 2022 for Lesueur's Tree Frog and the Southern Leaf Green Tree Frog as previously mentioned but which were not previously seen either in the earlier 2017 and 2020 surveys).
- There was a large drop in the detection rate for the Screaming Tree Frog. This species was not recorded in the earlier 2017 or 2020 survey. This may suggest a highly fluctuating local population, although the lower temperatures of the 2022 survey compared to the 2021 survey may also have played a role in lower activity levels and detection rates.
- There was a moderate drop in detection frequency of the Striped Marsh Frog from both the 2020 and 2021 results. However, this species was not detected at all during the initial 2017 survey. The lower temperatures may also account for this decrease in detection rates.
- There was a moderate increase in detection frequency for the Whistling Tree frog. This was one species of possible concern as noted in the 2021 report (and one reason why the survey period was brought forward to November). This species was recorded at over one-quarter of all sites in 2022 (compared to only 10% in 2021), but still well down on numbers seen in 2017 (at 100% of sites) and also marginally below the 2020 numbers (31%).
- Overall numbers of Peron's Tree Frog (13% of sites) are still well down from 2017 (50%) as well as 2020 (31%), but up from the very low 2021 result (5%). This low detection rate is still somewhat of concern for this species which is typically relatively common and widespread.

Overall, these results appear to show that on the whole, despite the lower detection rate for a number of species compared to last season, when looked at over the four years of survey (three conducted consecutively), the detection rates for most species appear to indicate a relatively stable amphibian community in the Mulloon Creek system. The lower detection rates for some species, including lack of record of two species from last season, could potentially be explained by either/combination of lower temperatures, resulting in lower activity levels, as well as lack of observer skill and/or low audio quality (in relation to frog calls over ambient noise such as the creek or wind).

Table 4 shows the detection frequency of species across the three survey seasons *and for dam/wetland sites only*.

**Table 4. Comparison of detection frequency of species between survey seasons (dam/wetland sites only).**

Common Name	2020 survey detection frequency	2021 survey detection frequency	2022 survey detection frequency
Plains Froglet	<u>50%</u>	<b>100%</b>	<b>100%</b>
Common Eastern Froglet	<u>38%</u>	50%	<b>100%</b>
Eastern Banjo Frog	<u>0%</u>	13%	<b>38%</b>
Striped Marsh Frog	<u>13%</u>	<b>38%</b>	<u>13%</u>
Spotted Grass Frog	<u>63%</u>	<b>100%</b>	88%
Peron's Tree Frog	<b>63%</b>	50%	<u>38%</u>
Screaming Tree Frog	<u>0%</u>	<b>75%</b>	<u>0%</u>
Whistling Tree Frog	38%	<u>13%</u>	<b>50%</b>
Smooth Toadlet	38%	38%	38%

*\*Bold text represents year with highest recorded detection frequency.*

In comparison with previous years' results for the dam/wetland site surveys, it is noted that all except one previously detected species; the Screaming Tree Frog, was positively recorded at a dam/wetland site during this survey (this species was detected at 6/8 sites last (2021) season but was not recorded at any site in the earlier 2020 season).

This (2022) season saw the highest or equal highest detection frequency for four of the eight species, including the Plains Froglet, Common Eastern Froglet, Eastern Banjo Frog and Whistling Tree Frog, with the Plains Froglet and Common Eastern Froglet both recorded at all eight sites.

Two species, the Striped Marsh Frog and Peron's Tree Frog both had their lowest recorded detection frequency over the three consecutive years' survey of dam/wetland sites at MCHF. For the Peron's Tree Frog, this species has previously been discussed as being of potential concern (see last season's report, PATH Co, 2022), with a low and possibly declining detection rate across the study area. As mentioned above for stream sites, this species also recorded the second lowest detection rate (at only 13% of sites) over the four surveys behind last (2021) season's record of 5%. Given these results, there is still some concern about the health or status of the population for this species in the study area, and potentially further across its range as discussed in the 2021 season's report (Patmore, 2022; see also Rowley and Rose, 2021).

For the Striped Marsh Frog, it had the equal lowest detection rate with the 2020 survey at 13% after being recorded at 38% of dam/wetland sites last season. There is no clear pattern or trend in the overall detection for this species overall when looking at the stream sites also, although the species did record its second lowest detection rate over the four seasons of stream surveys (it was not detected in 2017, but numbers were down, less than half, of the sites it was recorded at for the 2020 and 2021 seasons, see Table 3). Despite the lower numbers of this species, there are no known reports of any decline in



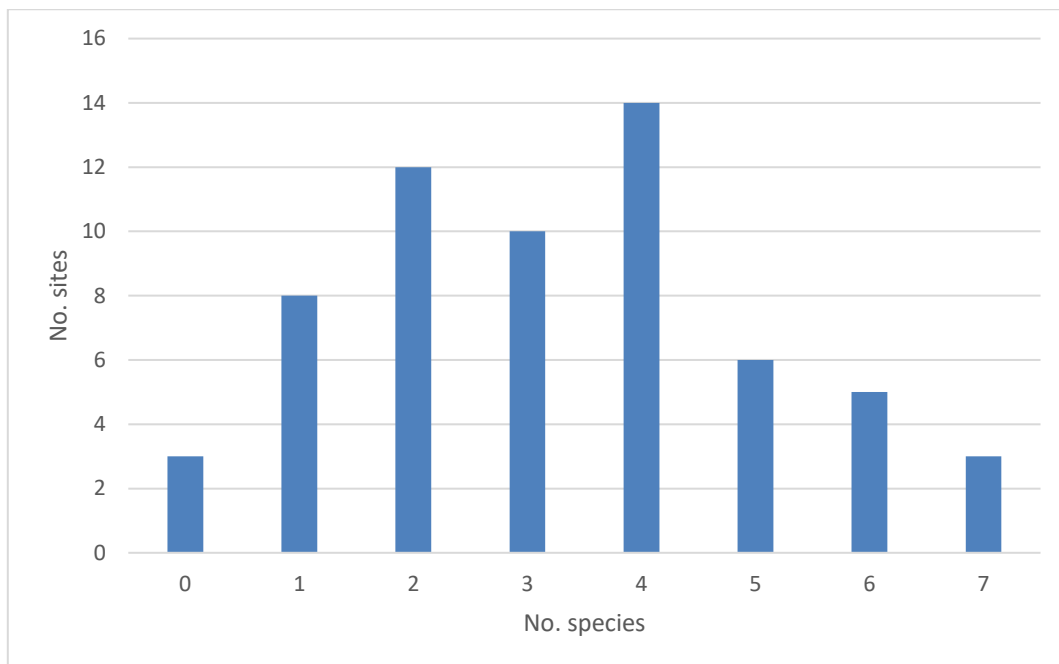
numbers further across its range, and based on these results, there is no obvious cause for any concern about the health of the local population or the species more broadly.

In general, the results for the dam/wetland surveys indicate a relatively robust and healthy local amphibian community. Of particular note, the estimated abundance of frogs (estimated number of individuals calling) was quite for most species and at most sites (pers. obs.).

### 3.2.1 Species richness at sites

The species richness per site describes the total number of species detected at a single site. The average number of species detected per site/survey across all 69 sites in total (61 stream and 8 dam/wetland sites) was 3.42 species per site. This included an average of 3.26 species per stream site and an average of 4.63 species per dam/wetland site, discussed separately below.

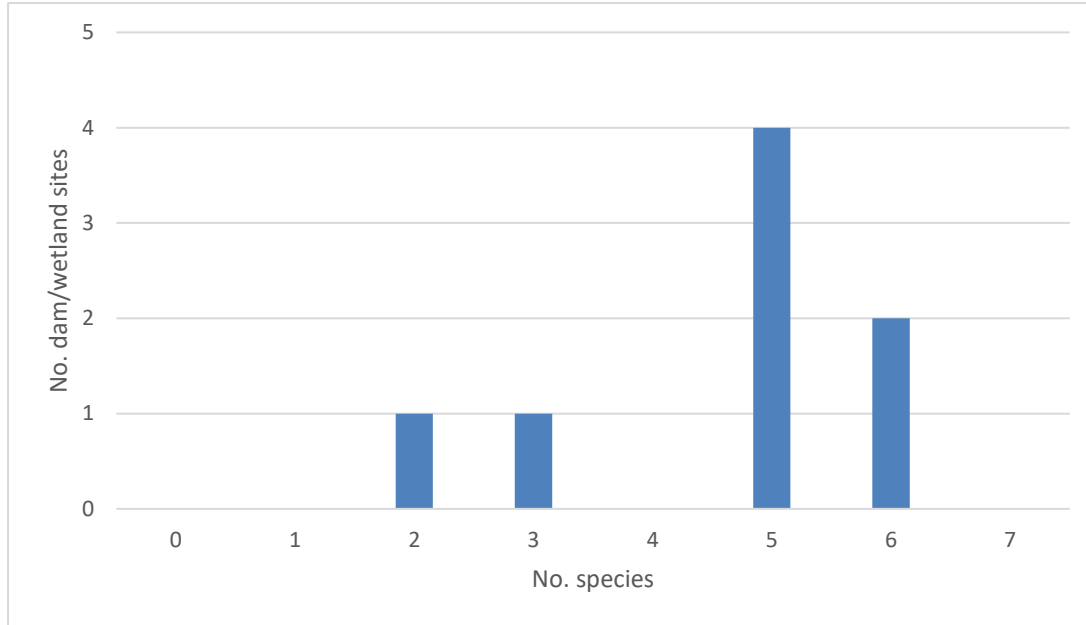
For the (61) stream sites along Mulloon Creek, the greatest number of species found at any one site during the surveys was 7 species, recorded at three sites (T\_17\_4; T\_20\_1 & T\_33\_4). Five sites recorded six (6) species, six sites recorded five (5) species, 14 sites recorded four (4) species, 10 sites recorded three (3) species, 12 sites recorded two (2) species, eight sites recorded only one (1) frog species and three sites did not record any frogs at all (0 species); see Figure 10 below.



**Figure 10. Species richness at stream sites along Mulloon Creek during the 2022 frog surveys.**

The average species richness (3.26 species per site) of stream sites recorded in this current (2022) season's survey represents a minor decrease in the average species richness of stream sites compared to the previous 2021 season's survey (of 3.67 species per site). Compared to the earlier surveys, it is an increase on the earlier 2020 season's survey result of 2.44 species per site, and a decrease on the 2017 season's survey result of 3.68 species per site (although the 2017 recorded a maximum of only 6 species at a single site, compared with 7 species this year and only 5 species in 2020).

For the (8) dam/wetland sites, the greatest number of species found at any one site during the surveys was 6 species that were recorded at two of the dam/wetland sites (D4 and W6). Of the remaining six dam/wetland sites, four sites recorded five (5) species, no sites recorded four (4) species, only one site (D31) recorded three (3) species, and only one site (D30) recorded two (2) species, with no dam/wetland sites recording fewer species than this (Figure 11).



**Figure 11. Species richness at dam/wetland sites at MCHF during the 2022 frog surveys.**

This year's findings (of 4.63 species per dam/wetland site) is generally similar to the previous (2021) season's findings of 4.75 species per dam/wetland site, and which also only recorded a maximum of 6 species at a single site. Compared to the earlier surveys, it is an increase on the 2020 season's survey result of only 3.0 species per dam/wetland site, as well as a maximum number of species for a single site of only four (4) species. The dam/wetland sites were not included in the original 2017 survey.

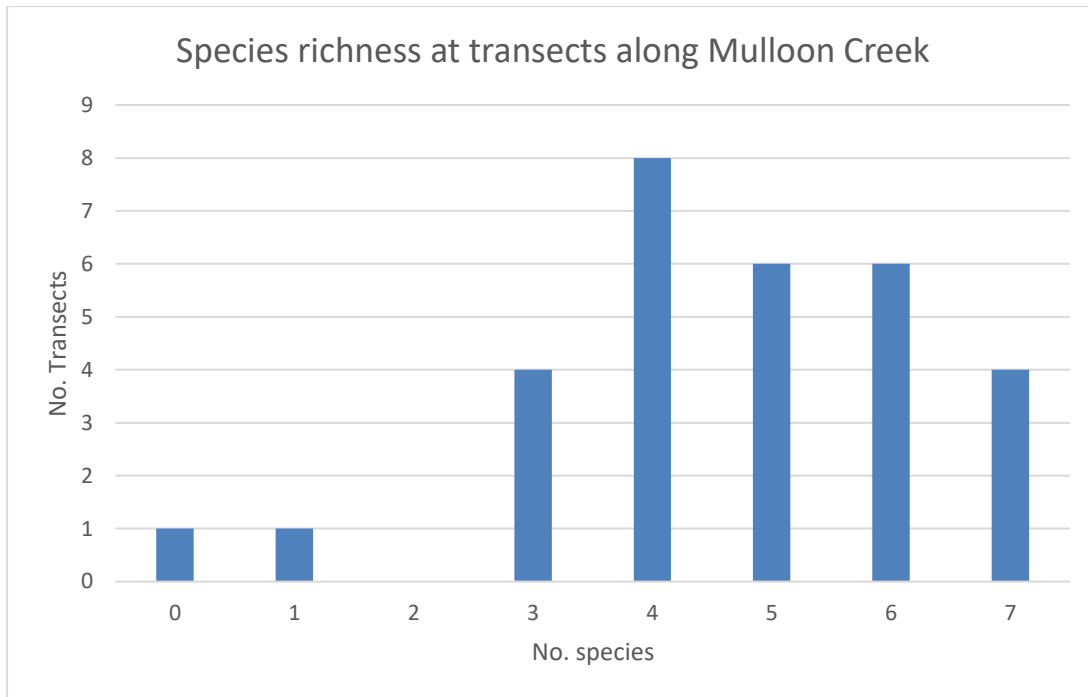
### 3.2.2 Species richness at transects

The species richness at transects describes the total number of species detected at each transect (i.e. total species recorded combined for both sites T<sub>x</sub>\_1 & T<sub>x</sub>\_4). For this assessment, the dam/wetland sites were discounted as these sites did not involve a transect with two survey sites.

For the transects along Mulloon Creek, an average of 4.63 species per transect were detected across the 30 (full/completed) transects in this season's survey. The greatest number of species found at any single transect during the surveys remained at seven (7) species, the same as the highest single site score, but was recorded at four transects (whereas only three sites recorded seven (7) species, indicating some transects recorded a higher combined species richness than either of the two sites that comprise the transect). Six transects recorded 6 species, and six transects also recorded 5 species, eight transects recorded 4 species, four transects recorded 3 species, no transect recorded two species, and one transect recorded a single species (T<sub>1</sub>, recorded C).

*signifera* only). Additionally, one transect (T\_10) failed to record a single species at either site (see Figure 12).

Just under half (13/30) of the transects completed had an increased combined number of species for the transect than for one of the (i.e. the highest) individual site species count (for example, each site may have recorded three species, but with a different composition of species at each site, the combined species count for the transect was higher at 4 or more species; the full results at Appendix A and in the electronic file show this information in detail).



**Figure 12. Species richness at stream transects along Mulloon Creek during the 2022 frog surveys.**

The average species richness recorded per transect (4.63) in this season's (2022) survey represents a minor decrease in the average species richness of stream transects compared to the previous 2022 survey of 4.9 species per transect. However, it is still higher than the 2020 result of 3.56 species per transect. The 2017 survey obtained a result of 5 species per transect, and also recorded a maximum of 7 species at a single transect, compared with a maximum of 8 species at a single transect in 2021 and only 5 species in 2020. These results indicate that the overall species richness of the frog community within the study area is relatively stable and indicative of an overall healthy and stable community.

## 4 DISCUSSION AND MANAGEMENT RECOMMENDATIONS

### 4.1 Discussion

The November 2022 frog surveys conducted at Mulloon Creek were undertaken at 62 stream sites being located within (at either end of) 31 existing RARC transects, as well as at 8 dam/wetland sites. These are generally the same sites surveyed during the previous December 2021 surveys (30 transects) and earlier December 2020 surveys (only 19 transects for that year).

For this 2022 season's survey, 5-minute audio recording was undertaken at all sites for later acoustic detection/identification of calling frogs and was conducted on a single night on 9<sup>th</sup> November 2022. Conditions for the frog surveys were generally good. Although temperature levels were a little lower than the previous and 2020 and 2021 seasons, they were still considered suitable to encourage calling activity. Water levels within the creek and dam/wetland sites were generally good after a preceding period of moderate to high rainfall in mid-Spring 2022, including (22mm) on the day/night before the surveys (BoM; Lockhart Bungendore readings), helping to stimulate frog activity.

The observed aquatic habitat conditions for frogs within the study area on the whole were relatively good. As noted, there water levels were moderately high, and stream flow rates were on average higher than the previous year. Emergent vegetation cover results were not notably dissimilar with last (2021) season's results and higher than the earlier 2020 results, indicating that on the whole across the entire system, emergent vegetation cover values appear to have increased marginally over the past few seasons. Several consecutive years of good rainfall and relatively high stream levels may have contributed to this increase (although some observer/recorder bias cannot be discounted from influencing the results).

There was however a minor but notable reduction in the fringe/edge vegetation cover scores for this current (2022) season when compared with the previous two seasons' surveys. There is no obvious (single) factor that may have contributed to this result, particularly given the large area/scale of the study area and multitude of properties with different management regimes. Seasonal climatic factors also do not well explain this result given good rainfall in the area during early-mid Spring leading up to the surveys, suggesting vegetation cover levels should have been (as) high. Again, some observer/recorder bias cannot be discounted from influencing the results obtained, and so no definitive conclusion can be drawn as what the actual extent of any changes in fringe/edge vegetation condition might be across the system and/or what any changes may be related to.

Further assessment of these results may be required to confirm whether these findings represent a real change in vegetation cover at sites over the years. In this instance, a 'within' site comparison between years (i.e. looking at scores for the same site each year) could be beneficial, but is beyond the scope of this current study which is primarily to assess the frog population status.

The acoustic-based frog monitoring surveys undertaken this 2022 season found that the Mulloon Creek study area study continues to support a relatively healthy frog community within the stream habitats as well as at the additional dam/wetland sites within the MCHF property. This season, a total of 9 frog species recorded during the study. This is two less than the previous (2021) season's result of 11 species, but one more than the earlier 2020 survey of 8 species, and two more than the 2017 survey of 7 species.

The two species recorded last year but not detected this year are Lesueur's Tree Frog and the Southern Leaf Green Tree Frog. These species were previously recorded in the Landtasia property in the upper reaches of Mulloon Creek (Transects 2-6), where there is a more intact rocky stream bed. The failure to detect these species this season may be a result of observer skill and audio-recording quality as it was noted that both these species were directly recorded by the on-site observer last season who was relatively skilled/experienced in frog identification. This season, the on-site observer was less skilled and did not make any direct records of calling frogs. The audio recording for these sites was also affected by the noise of the creek and so later acoustic identification of calling frogs from the audio records was difficult at these sites. Consequently, there is not much that can be inferred from the lack of records of these two species for this season's survey.

All except three sites (T\_10\_1; T\_10\_4 and T\_13\_4) within the study area recorded at least one species of frog and the average number of species per site (as a measure of species richness) was 3.42 including an average of 3.26 species per stream site and an average of 4.63 species per dam/wetland site. These numbers are slightly down on the previous (2021) season's results of 3.67 species per stream but an increase on the earlier 2020 season's survey result of 2.44 species per stream site, and a decrease on the initial 2017 season's survey result of 3.68.

For species richness at the dam/wetland sites, this (2022) season's result of 4.63 species per site was comparable to the previous (2021) season's findings of 4.75 species per dam/wetland site, and an increase on the 2020 season's survey result of only 3.0 species per dam/wetland (dam/wetland sites were not included in the initial 2017 survey).

A similar pattern was found when looking at species richness at survey transects (which excludes dam/wetland sites) which for this season was recorded at 4.63 species per transect. Again, this is marginally down from the previous 2021 season survey which recorded an average of 4.9 species per transect and down also from the initial 2017 survey result of 5 species per transect, but more than the 2020 result of 3.56 species per transect.

Overall, the maximum number of species detected at a single stream site was 7 species, the same result for the maximum number of species detected at a single transect. This is similar to last season's 2021 survey, which also recorded a highest total of 7 species at a single stream site, but down on the highest number of species recorded at a transect of 8 species. This season's results compare well against the earlier 2017 and 2020 surveys periods which recorded a maximum of 6 and 5 species for a stream site and 7 and 5 species at a stream transect respectively.

When looking at individual species records this 2022 survey season, it was noted that the Common Eastern Froglet was the most commonly/frequently recorded species, being

detected at 62 of the 69 (or 90%) of the sites surveyed in total. Other species recorded regularly (i.e. at more than 50% of the surveys sites) included the Spotted Grass Frog (43/69 sites), Plains Froglet (40/69 sites) and the Eastern Banjo Frog (37/69 sites). The least frequently recorded species this 2022 survey season was the Screaming Tree Frog, recorded at only 2/69 (3%) of sites, including no records at any of the dam/wetland sites. Also of note was the of any records at all of Lesueur's Tree Frog or the Southern Leaf Green Tree Frog, which had been previously recorded in last season's 2021 surveys (only).

When looking at patterns or changes of records over the seasons for each of the frog species individually, the 2022 season survey saw the highest detection frequency rate for only one species, the Banjo Frog, and conversely, did not record the lowest detection rate for any species over the four years of surveys completed (noting the lack of observations in 2022 for Lesueur's Tree Frog and the Southern Leaf Green Tree Frog as previously mentioned but which were not previously seen either in the earlier 2017 and 2020 surveys). There was a large drop in the detection rate for the Screaming Tree Frog compared to the 2021 season, however this species was not recorded in the earlier 2017 or 2020 survey. This may suggest a highly fluctuating local population, although the lower temperatures of the 2022 survey compared to the 2021 survey may also have played a role in lower activity levels and detection rates. There was also a moderate drop in detection frequency of the Striped Marsh Frog from both the 2020 and 2021 results. However, this species was not detected at all during the initial 2017 survey. The lower temperatures may also account for this decrease in detection rates.

There was a moderate increase in detection frequency for the Whistling Tree frog. This was one species of possible concern as noted in the 2021 report (and one reason why the survey period was brought forward to November). This species was recorded at over one-quarter of all sites in 2022 (compared to only 10% in 2021), but still well down on numbers seen in 2017 (at 100% of sites) and also marginally below the 2020 numbers (31%). The overall numbers of Peron's Tree Frog (13% of sites) are still well down from 2017 (50%) as well as 2020 (31%), but up from the very low 2021 result (5%). This low detection rate is still somewhat of concern for this species which is typically relatively common and widespread.

Overall, these results appear to show that most frog species present in the Mulloon Creek system appear to have relatively stable local populations. However, some species may have local populations that are either highly fluctuating in distribution and abundance, or, may in fact be declining. Of particular note is the Peron's Tree Frog which still occurs at very low detection rates compared to earlier surveys, and as mentioned previously, this species may be declining more broadly across NSW. The lack of records of Lesueur's Tree Frog and the Southern Leaf Green Tree Frog is not yet of concern as these species were recorded in low numbers by a skilled on-site observer and only in the upper reaches of the Mulloon Creek system where suitable rocky substrate habitat exists. They had not been previously recorded in earlier surveys or in sites further downstream from Landtasia. It is recommended that a skilled observer conduct the following season's survey, or, that better quality audio recording is undertaken (to eliminate/reduce the background noise of the creek and maximise recording of frog calling).

The seemingly large drop in the detection frequency of the Screaming Tree Frog is not well understood. Of note, it could be that there is no real decline in numbers but that activity levels of this species may be reduced this season compared to last season, and that the cooler temperatures of this season may have played a role in this. Given this species wasn't recorded during the earlier 2017 or 2020 surveys, there is no real pattern to indicate what the current status of the local population might be. Further consideration of this may be required if the next season's monitoring fails to detect the species (in adequate numbers across the study area).

In summary, some possible reasons for the perceived declines in overall species richness as well as the detection rate of certain species (especially between 2021 and 2022 seasons results) could include a variety of factors, potentially acting independently or in conjunction with each other, including notably:

- Cooler temperatures this season which may have reduced overall calling activity levels for some species/at some sites.
- Higher stream flow rates at some sites contributed to greater background noise in the audio recording. For some sites it was very hard to ID calling frogs over the stream noise.
- Observer skill; last season had some sites surveyed by relatively skilled staff that were able to ID frogs on-site but were not available this season (this is particularly notable at noisy stream sites such as Landtasia).
- Local populations that fluctuate seasonally but overall, in the long-term are relatively stable (the Screaming Tree Frog and Striped Marsh Frog would appear to be candidates for this)
- Actual declines in local population abundance and distribution for some species (Peron's Tree Frog would be a possible candidate for this – this is one of a number of species with recent reports of high mortality events, likely attributable to the amphibian chytrid fungus. Further research may be required to help better understand whether there is a real decline in the occurrence of this species, and whether that may be attributable to the chytrid fungus).

Possible management and further research recommendations to ensure the ongoing health and future potential increase in the frog community within the catchment are discussed below.

## **4.2 Recommendations**

### **4.2.1 Land and habitat management**

The land/habitat management recommendations related to ensuring the maintenance of a viable (sustainable and diverse) frog community at Mulloon Creek are relatively unchanged from those proposed in the previous 2020 and 2021 survey season reports (Patmore, 2021 and Patmore, 2022). As indicated in that report, these are primarily for consideration (not mandatory or otherwise urgently required) and include the following:

1. Continue to maintain in good repair all existing fencing along the creek to exclude/control livestock access.

2. Consider constructing additional fencing along sections of the creek that are currently unfenced.
3. Reduce/manage degradation of in-stream and riparian habitat through addressing any active sediment and erosion inputs.

As also noted in the initial 2020 survey season report (Patmore 2021), a strategy for the longer-term management/removal of Blackberry along creek banks should be considered. However, this removal needs to be balanced against its current role in maintaining bank stability, thus, some form of replacement planting would be required. This combined with the difficulty of removal of the Blackberry could become a prohibitively costly exercise. Consequently, this factor is mentioned for consideration only, but not a specific recommendation for implementation.

As also noted in the 2020 survey report, it is recommended consideration be given to future possible longer-term habitat creation, enhancement, or expansion for frogs in the catchment. These include:

- Construction/establishment of further artificial wetlands within MCHF (as discussed and recommended in the *Habitat Assessment & Translocation Strategy for the Green and Golden Bell Frog* report prepared by PATH Co (2019). This could also extend to other properties as well. The general approach should be for creation of a more natural 'wetland' feature as opposed to standard farm dams (typically used for stock watering etc). Additionally, ensuring connectivity and proximity to the creek is important for new wetland habitats to function as suitable amphibian habitats.
- Consider further riparian revegetation along sections of the creek where natural/native riparian vegetation species are limited.

#### **4.2.2 Further research**

Recommendations for further/ongoing research and monitoring to assist with managing the site for the benefit and maintenance of frog communities include mainly the recommendation for the continuation of this current monitoring program, although with some possible additions/alterations, including:

- If time/budgets permit, consider increasing the survey period to include two separate nights of Spring-Summer survey; ideally in early November and mid-late December. This will not only improve the overall chances of detection of species (and is more in-line with amphibian survey guidelines for many species) but will allow the surveys to be spread out which can help account for potential inclement weather. This may help ensure surveys during warmer weather with high calling activity levels (and may help to better ascertain overall status of species such as the Screaming Tree Frog whose numbers were well-down this season compared to last season which was undertaken during warmer weather).
- In addition or as an alternative to the above, if budget permits consider an Autumn survey to detect other species (such as *Pseudophryne* sp.).
- Consider further detailed investigations into the potential declining occurrence of Peron's Tree Frog. As noted above, earlier survey timing, including potentially second additional survey occasion, would help increase the likelihood of



detection. Therefore, if detection rates of these species remains low despite the increased effort, this may be a sign of actual (local) population decline. Although it is likely that if there is a decline in these species, the amphibian chytrid fungus would be responsible, this is not definite. Further assessment of the causes of decline may be warranted, including possibly undertaking a chytrid assessment of the population (likely through a swab analysis of frogs although other assessment techniques may be available).

- If possible, seek to ensure that surveys at Landtasia are undertaken by more experienced staff to help identify/confirm occurrence of Lesueur's Tree Frog and Southern Leaf Green Tree Frog. If not possible, seek to ensure better quality audio-recording of frogs over stream noise. This may involve having the recorder positioned further away from the stream. A longer recording time (of 10mins) may also be considered for these sites.
- Ensure that the habitat assessment component of the study continue to be undertaken diurnally (and separate to the nocturnal frog survey) and completed either by a single observer (as was the case for the 2021 and 2022 surveys), or, if undertaken by multiple observers, that some initial training be held to 'calibrate' their estimates. This is necessary to ensure consistency of data collection to enable more effective comparisons between sites and between seasons.
- Consider increasing information on vegetation parameters, including noting dominant species of emergent aquatic and fringe/edge vegetation. Tracking any changes in the vegetation composition and structure over time would be useful for comparisons with any potential changes in frog species richness (and abundance) over time that could be attributable to these vegetation changes.
- Consider also adding some additional parameters such as more water chemistry variables (e.g. pH, Conductivity etc). Note that water chemistry variables along a continuous aquatic system like Mulloon Creek may only need to be assessed at a smaller sub-set of sites/transects.
- If time/budgets permit, consider undertaking additional surveys of other non-stream habitats (i.e. additional dams/wetlands) within not only MCHF, but other properties within the study area.
- Finally, although it is beyond the current scope of this study, it is recommended that for the final report at the conclusion of the (5-year) annual monitoring surveys, that further site-specific assessments are completed to identify which sites have greater frog species richness and to compare the habitat features of these sites against other sites of low(er) species richness. This would include a comparison of other factors not included in the current habitat assessment, including distance to in-stream interventions/structures (i.e. leaky weirs), stream morphology and a greater, in-depth assessment of vegetation values (as mentioned above). The aim of this would be to identify and better understand which habitat parameters may/are likely to be important in determining overall habitat quality for frogs. Consequently, this information could help to inform any future targeted land management activities/stream interventions to improve habitat quality for frogs and overall biodiversity values within the catchment.

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<https://www.abc.net.au/news/2021-07-29/dead-shrivelled-frogs-turning-up-eastern-australia-help-find-why/100331042>



T_60_1	x (1-5)	x (6-20)	x (1-5)		x (1-5)							4	4
T_60_4		x (6-20)			x (1-5)							2	
T_61_1	x (1-5)	x (1-5)	x (1-5)									3	6
T_61_4	x (6-20)	x (1-5)	x (1-5)		x (1-5)			x (1-5)		x (1-5)		6	
<b>Total Sites/61</b>	32	54	34	7	36	0	0	8	2	17	8	Max sp/site = 7 Total sp = 9	Max sp/ transect = 7
<b>% Sites</b>	52	89	56	11	59	0	0	13	3	28	13	Avg sp/site = 3.26	Avg sp/ transect = 4.63

For Transect totals; bold number indicates an increase in number of species/transect from number species/site

Table A2. Frog species records at the (8) dam and wetland sites at MCHF during the **November 2022 Frog Surveys**

Site	<i>Cri. par</i>	<i>Cri. sig</i>	<i>Lim. dum</i>	<i>Lim. per</i>	<i>Lim. tas</i>	<i>Lit. les</i>	<i>Lit. nud</i>	<i>Lit. per</i>	<i>Lit. qui</i>	<i>Lit. ver</i>	<i>Upe. lae</i>	<b>Sp. Total/ Site</b>
D3	x (6-20)	x (6-20)	x (1-5)		x (6-20)						x (6-20)	5
D4	x (6-20)	x (6-20)	x (1-5)		x (6-20)					x (1-5)	x (6-20)	6
W6	x (6-20)	x (6-20)	x (1-5)	x (6-20)	x (6-20)					x (6-20)		6
D26	x (6-20)	x (21-50)			x (6-20)			x (6-20)		x (1-5)		5
D27/28	x (21-50)	x (21-50)			x (21-50)			x (1-5)			x (6-20)	5
D30	x (6-20)	x (6-20)										2
D31	x (6-20)	x (6-20)			x (6-20)							3
D32	x (21-50)	x (6-20)			x (21-50)			x (6-20)		x (6-20)		5
<b>Total Sites/8</b>	8	8	3	1	7			3		4	3	Max sp/site = 6 Total sp = 8
<b>% Sites</b>	100	100	38	13	88			38		50	38	Avg sp/site = 4.63

Species Code:

*C. par* = *Crinia parinsignifera*

*C. sig.* = *Crinia signifera*

*Lim. dum* = *Limnodynastes dumerilii*

*Lim. per.* = *Limnodynastes peronii*

*Lim. tas.* = *Limnodynastes tasmaniensis*

*Lit. per.* = *Litoria peronii*

*Lit. qui.* = *Litoria quiritatus*

*Lit. ver.* = *Litoria verreauxii*

*U. lae.* = *Uperoleia laevigata*

## Appendix B. Habitat Survey Data

Table B1. Habitat Survey Details at (31) RARC transects (n=62 sites) along Mulloon Creek during the November 2022 Frog Surveys

Site Ref No	Sky	Wind	Air Temp	Water Temp	Water Depth	Pond Level	Water Flow	Vertical Water Level Drop (m)	Area Exposed Soil (m)		Emergent Aquatic Veg Cover	Fringe/Edge Veg Cover	Pond Shading	Mowing? (Y/N)	Width of buffer
									Min	Max					
T_2_1	3	1	NR	16.5	2	3	3	0.5	0	0.5	1	5	2	N	3
T_2_4	3	1	NR	16.5	2	3	3	1	0	1.5	2	3	3	N	3
T_4_1	3	1	NR	16	2	3	3	2.5	0	0.5	1	6	3	N	3
T_4_4	3	1	NR	16	2	3	3	1.25	0.5	2	1	3	3	N	3
T_6_1	2	3	NR	15.5	2	3	3	1.25	0.25	1	1	4	4	N	3
T_6_4	2	3	NR	15.5	2	3	3	1.5	0.25	1	1	4	3	N	3
T_10_1	3	1	16	17	2	3	3	0.5	0.5	1	1	2	3	N	3
T_10_4	3	1	16	17	2	3	3	2	0.5	1.5	1	2	3	N	3
T_11_1	2	1	12.6	16.5	2	3	3	1.5	0.5	1.5	1	2	5	N	3
T_11_4	2	1	12.7	16.5	2	3	2	1.5	0	0.5	1	6	3	N	3
T_12_1	2	1	15	17	2	3	4	1.25	0	0.5	3	6	4	N	3
T_12_4	2	2	15	17	2	3	3	1.5	0.5	1	3	4	3	N	3
T_13_1	2	1	11.3	16.5	2	3	3	1.5	0.5	1	3	5	5	N	3
T_13_4	2	1	11.8	16.5	2	3	3	1.5	0.25	0.5	3	6	5	N	3
T_14_1	2	1	12.1	16.5	2	2	3	1.25	0	0.25	3	7	2	N	3
T_14_4	2	1	12.6	16.5	2	3	4	1.5	0	0.25	2	3	5	N	3
T_15_1	1	1	12	16.5	2	3	3	1.5	0	0.5	2	5	4	N	3
T_15_4	1	1	12	16.5	2	3	3	1.5	0.5	4	3	6	4	N	3
T_16_1	1	1	12	16.5	2	3	3	1.5	0	0.5	2	6	3	N	3
T_16_4	1	1	12	16.5	2	3	3	1.5	0.25	0.5	2	6	5	N	3
T_17_1	1	1	12	16.5	2	2	2	0.5	0	0.5	5	7	5	N	3
T_17_4	1	1	12	17	2	2	2	0.5	0	0.5	5	7	4	N	3
T_18_1	1	1	13.5	17	2	2	3	0.5	0.25	1	3	5	3	N	3
T_18_4	1	1	14	17	2	2	3	0.5	0	0.5	3	5	2	N	3
T_19_1	1	1	14	17	2	2	3	1	0	0.5	3	7	2	N	3
T_19_4	1	1	14	17	2	2	3	1	0	0.25	3	7	2	N	3
T_20_1	1	2	13	16.5	2	3	3	2.5	0.2	1.5	4	7	6	N	3
T_20_4	1	3	12	16.5	2	3	3	2.5	0.5	1.5	5	7	3	N	3
T_21_1	1	2	14.5	17.5	2	2	3	0.5	0	0.5	3	7	2	N	3
T_21_4	1	1	14	17.5	2	3	2	1	0.25	2	2	6	3	N	3
T_22_1	1	2	13	17	2	3	3	1.5	0.25	3	2	6	2	N	3
T_22_4	2	3	13	17	2	3	3	1.75	0	1.5	3	7	3	N	3
T_23_1	2	2	13	17	2	3	3	1.5	0.25	5	2	5	4	N	3
T_23_4	2	1	12.5	17	2	3	3	2	0.25	1	3	6	3	N	3
T_24_1	2	1	12	17	2	2	3	0.75	0	0.25	2	7	4	N	3
T_24_4	2	1	12	17	2	3	3	1	0	2	2	5	4	N	3
T_25_1	1	1	13	17.5	2	3	3	1.5	0.25	2	2	4	4	N	3
T_25_4	1	1	13	17.5	2	3	3	1.5	0.25	0.5	2	5	4	N	3
T_26_1	1	2	12.5	17	2	3	3	1.5	0.25	1	2	6	3	N	3
T_26_4	2	2	12.5	17	2	3	3	1.5	0.25	1	2	5	1	N	3

T_27_1	1	2	12	17	2	3	4	1.5	0	1	2	6	3	N	3
T_27_4	NR	NR	NR	NR	2	3	3	1.5	0.25	1	2	5	5	N	3
T_28_1	1	2	11.5	17	2	3	3	1.5	0	0.5	2	6	4	N	3
T_28_4	NR	NR	NR	NR	2	3	3	2	0.25	1	2	5	5	N	3
T_32_1	1	2	18	21	1	3	2	1.25	0	0	6	7	1	N	3
T_32_4	1	1	NR	19	2	3	2	1.25	0	0.25	NR	NR	5	N	3
T_33_1	NR	NR	13	19	2	3	3	2.5	0.25	0.5	3	NR	5	N	3
T_33_4	2	3	12	19	1	3	2	1.25	0	0.25	5	6	1	N	3
T_34_1	1	2	12	22	1	2	2	0.5	0	0.25	6	7	1	N	3
T_34_4	NR	NR	13	21	1	3	3	1.5	0.25	2	4	5	1	N	3
T_39_1	1		15	18	2	2	3	0.75	0	0.25	2	7	6	N	3
T_39_4	2	3	15	18	2	2	3	0.75	0	0.5	4	5	4	N	3
T_42_1	2	2	14	17	2	2	3	0.75	0	0.25	4	7	2	N	3
T_42_4	2	2	14	17	2	3	3	NR	NR	NR	2	7	4	N	3
T_43_1	1	2	13	16	2	3	3	2	0	0.5	2	6	3	N	3
T_43_4	1	2	12	16	2	3	3	2	0.5	2	2	5	5	N	3
T_44_1	1	2	13	17	2	3	3	2	0.25	5	2	4	4	N	3
T_44_4	1	2	10	17	2	3	3	2	0.25	2	2	5	4	N	3
T_60_1	1	3	14	17.5	1	3	3	2.5	0	0.5	5	7	1	N	3
T_60_4	1	3	14	17.5	2	3	3	2.75	0.5	2	6	7	1	N	3
T_61_1	1	3	14	17.5	2	3	3	3	0.25	2	5	6	1	N	3
T_61_4	1	3	14	17.5	1	3	3	3	0	2	5	7	2	N	3

NR = Not Recorded on data sheet

Table B2. Habitat Survey Details at (8) Dam/Wetland sites at MCHF during the November 2022 Frog Surveys

Site Ref No	Sky	Wind	Air Temp	Water Temp	Water Depth	Pond Level	Water Flow	Vertical Water Level Drop (m)	Area Exposed Soil (m)		Emergent Aquatic Veg Cover	Fringe/Edge Veg Cover	Pond Shading	Mowing? (Y/N)	Width of buffer
									Min	Max					
D3	2	2	14.5	19.5	2	1	1	0.1	0	0.1	2	7	1	N	3
D4	2	2	14.5	19.5	2	1	1	0.1	0	0.2	3	6	1	N	2
W6	2	2	14	18.5	2	1	1	0	0	0	7	7	2	N	3
D26	2	2	16	19.5	2	1	1	0	0	0.3	2	7	3	Y	2
D27/28	2	2	16	19.5	2	1	1	0	0	0.1	2	6	2	Y	2
D30	2	2	15.5	19	2	1	1	0.1	0	0.5	2	5	2	Y	2
D31	2	2	15.5	19	2	1	1	0.1	0	0.3	2	5	2	N	2
D32	2	2	15	19.5	2	1	1	0.2	0	0.3	2	6	1	N	2

Table B3. Description of score categories for habitat variables in Tables B.1 and B.2

Sky (1 to 6)	Wind (1 to 4)	Water Depth (1 to 4)	Pond Level	Water Flow (1 to 4)	Emergent Aquatic Veg Cover	Fringe/Edge Veg Cover	Pond Shading	Width of buffer
1 = clear/few clouds	1 = Still	1 = <30	1 = Full	1 = Still	1 = none	1 = none	1 = none	1 = <1m
2 = Partly cloudy/variable	2 = Light Breeze	2 = >30	2 = Nearly Full	2 = Slow	2 = just localised	2 = just localised	2 = <10%	2 = 1-5m
3 = Cloudy/overcast	3 = Light Wind	3 = unknown	3 = Bank V. Exposed	3 = Moderate	3 = <25%	3 = <10% edge	3 = <25%	3 = >5m
4 = Fog	4 = Windy	4 = Dry	4 = Nearly Dry	4 = Fast	4 = <50%	4 = <25% edge	4 = <50%	
5 = Drizzle			5 = Dry		5 = <75%	5 = <50% edge	5 = <75%	
6 = Showers					6 = <100%	6 = <75% edge	6 = <100%	
					7 = entire pond	7 = <100% edge		
						8 = entire edge		

