APPENDIX B28-A ECOSM 2013: RESULTS OF SURVEYS FOR THE BOGGOMOSS SNAIL

NATHAN DAM AND PIPELINES PROJECT

RESULTS OF SURVEYS FOR THE BOGGOMOSS SNAIL

Prepared for

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Surveys of September / October 2012

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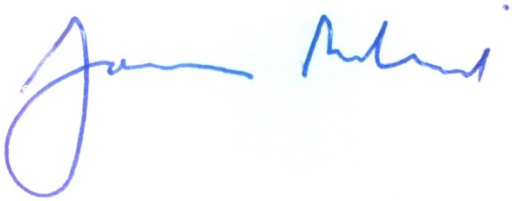
Signed :	
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1 Introduction

Ecological Survey & Management Pty Ltd (EcoSM) was engaged by Sinclair Knight Merz Pty Ltd (SKM) to lead further targeted surveys for the critically endangered Boggomoss Snail (*Adclarkia dawsonensis*) within the Taroom region of central Queensland. The surveys are primarily driven by the approvals process for the proposed Nathan Dam and Pipelines Project (the project).

The scope of work for this assessment was as follows:

- Testing a number of field sampling methods and subsequent approaches to estimating population size;
- Providing a population estimate for the species at Mt Rose Station using methods consistent with that used at other sites;
- Surveying potential habitat in an effort to locate new populations;
- Assessing the physical impact of recent flood events (2010, 2011); on the known habitat of the species.

2 Methodology

2.1 Selection of survey sites

This study focussed on the assessment of populations at sites known to be significant to the Boggomoss snail, as well as considering sites which had not been surveyed historically. The most important sites based on historic survey results are:

- Mt Rose (Boggomoss 14),
- Isla Delusion and
- Southend.

Live snails of various age classes have been found, sometimes on repeated occasions, at these sites so they are assumed to represent viable populations. This study sought to review the impact of consecutive flood events on populations of the boggomoss snail at known sites.

Two other boggomosses at Mt Rose (15 and 16) have been surveyed three times each but snails were only recorded on the second survey event. Confirmation of the status of these populations is of interest as they represent the only other confirmed records within the direct impact area of the proposed dam. As such, these boggomosses were targeted during 2012.

Boggomoss snails are restricted to the moister riparian (riverside) and boggomoss habitats on alluvial flats between Taroom and Theodore (Stanisic 2008). Most of this habitat has been cleared for farming and little original vegetation, and therefore possible habitat remains (Clarke & Spier-Ashcroft 2003). At the Isla-Delusion and Southend sites, the boggomoss snail is found in an area of riparian habitat in a stock and water reserve, which is contiguous with similar vegetation on adjacent private property. The vegetation is representative of Regional Ecosystem 11.3.25 under the Qld Vegetation Management Framework, described as "*Eucalyptus camaldulensis* or *E. tereticornis* open-forest to woodland.

SKM (2009) recorded the boggomoss snail from 15 sites within 11 discrete habitat patches, almost exclusively associated with Qld Blue Gum and Carnarvon Palm (*Livistona nitida*) forest to open forest. Within these forests, the boggomoss snail was recorded either under a deep accumulation of palm fronds or at the base of individual Palm trees, where moisture accumulates due to the drainage structure of the fronds and leaves.

Several new survey sites were selected upstream of the proposed dam within habitat which was consistent with that known to support the species and described above.

As the Mt Rose sites are the most upstream known locations for the species and they would be lost should the dam proceed, it is important to have confidence in any statements made regarding the upstream limit of distribution. Suitable habitat upstream of the dam inundation area was therefore targeted.

A total of 17 patches of suitable habitat (**Table 2** and **Figure 1)** were surveyed in 2012 within nine survey sites;

- three survey sites comprising historic known distribution (Southend, Isla Delusion and Mt Rose),
- three survey sites upstream of the inundation area (Palm Tree Creek, Taroom Common and Boggomoss Station) and
- three new survey sites downstream (Cockatoo Creek, Nardoo and Dawson floodplain west) from the proposed dam.

2.2 Distribution surveys

As with previous studies, active searches were completed at all sites firstly to determine the presence/absence of the species. All sites surveyed in 2012 were searched by either one team of five persons or one team of 2 persons using garden implements (rakes, forks) to sift through leaf litter and debris. Logs which were of small size were also lifted and inspected. Due to the variable team size, search effort is reported as person hours.

The minimum search effort at any patch was 15 minutes, and the maximum search effort was 5 hours. As such, search effort ranged from 1 person hour to 25 person hours per patch. The variation in survey effort across sites was driven by the size of the patch and the availability of suitable microhabitats for the snail. Sites with abundant leaf litter and debris were searched for longer than those sites with little or no available microhabitat.

The percentage of suitable microhabitat cover was measured over a 100m transect at each site at which the snail was recorded. This was recorded as the lineal intercept of suitable microhabitat on a 100m tape within the habitat patch.

Table 1 – 2012 Survey sites

Survey Site	Habitat Patch	Historic Site Reference	Habitat Type	Photographs
Taroom Common	12-1	NA, new site	Floodplain woodland of Dawson River dominated by Coolabah. Abundance of ephemeral wetlands with well-developed macrophyte cover. Soil conditions very moist and deep mulch present in many locations.	

Survey Site	Habitat Patch	Historic Site Reference	Habitat Type	Photographs
Taroom Common	12-2	NA, new site	Brigalow Woodland. Site located within Taroom Common on alluvial soils of the Dawson River. Limited development of leaf litter and woody debris. No waterbodies present.	
Taroom Common	12-3	NA, new site	Wetland fringed by Qld Blue Gum within Taroom Common. Limited or no midstorey development and very sparse groundcover. Abundant logs on margins but no vegetative cover, reducing potential shelter sites.	

Survey Site	Habitat Patch	Historic Site Reference	Habitat Type	Photographs
Nardoo	12-4	NA, new site	Carnarvon Palm Woodland on Anabranch of Dawson River. Open Forest of Carnarvon Palm Carnarvon Palm dominates the upper strata of vegetation, with limited midstorey Extensive accumulation of palm fronds and other leaf litter. Some piles of flood debris.	
Nardoo	12-5	NA, new site	Carnarvon Palm Woodland on Anabranch of Dawson River. Open Forest of Carnarvon Palm Carnarvon Palm dominates the upper strata of vegetation, with limited midstorey Extensive accumulation of palm fronds and other leaf litter. Some piles of flood debris.	

Survey Site	Habitat Patch	Historic Site Reference	Habitat Type	Photographs
Southend	12-6	D14, D15, VH24, VH25 (SKM 2009); Ad9, Ss12 (JKR Ecological 2011)	Woodland of Coolabah (Eucalyptus coolabah) and Queensland Blue Gum (Eucalyptus tereticornis) on the Dawson River. Evidence of prolonged inundation at depths of greater than 5m during recent flooding. Limited or no development of leaf litter layers of midstorey vegetation. Paucity of logs and other debris. Many ephemeral wetlands across floodplain at this location.	

Survey Site	Habitat Patch	Historic Site Reference	Habitat Type	Photographs
Isla-Delusion	12-7	Isla Delusion Camping Reserve (BAAM 2009); JR 16, JR 18 (SKM 2009);	Carnarvon Palm Woodland on Anabranch of Dawson River. Open Forest of Carnarvon Palm Carnarvon Palm dominates the upper strata of vegetation, with limited midstorey Extensive accumulation of palm fronds and other leaf litter. Some piles of flood debris.	

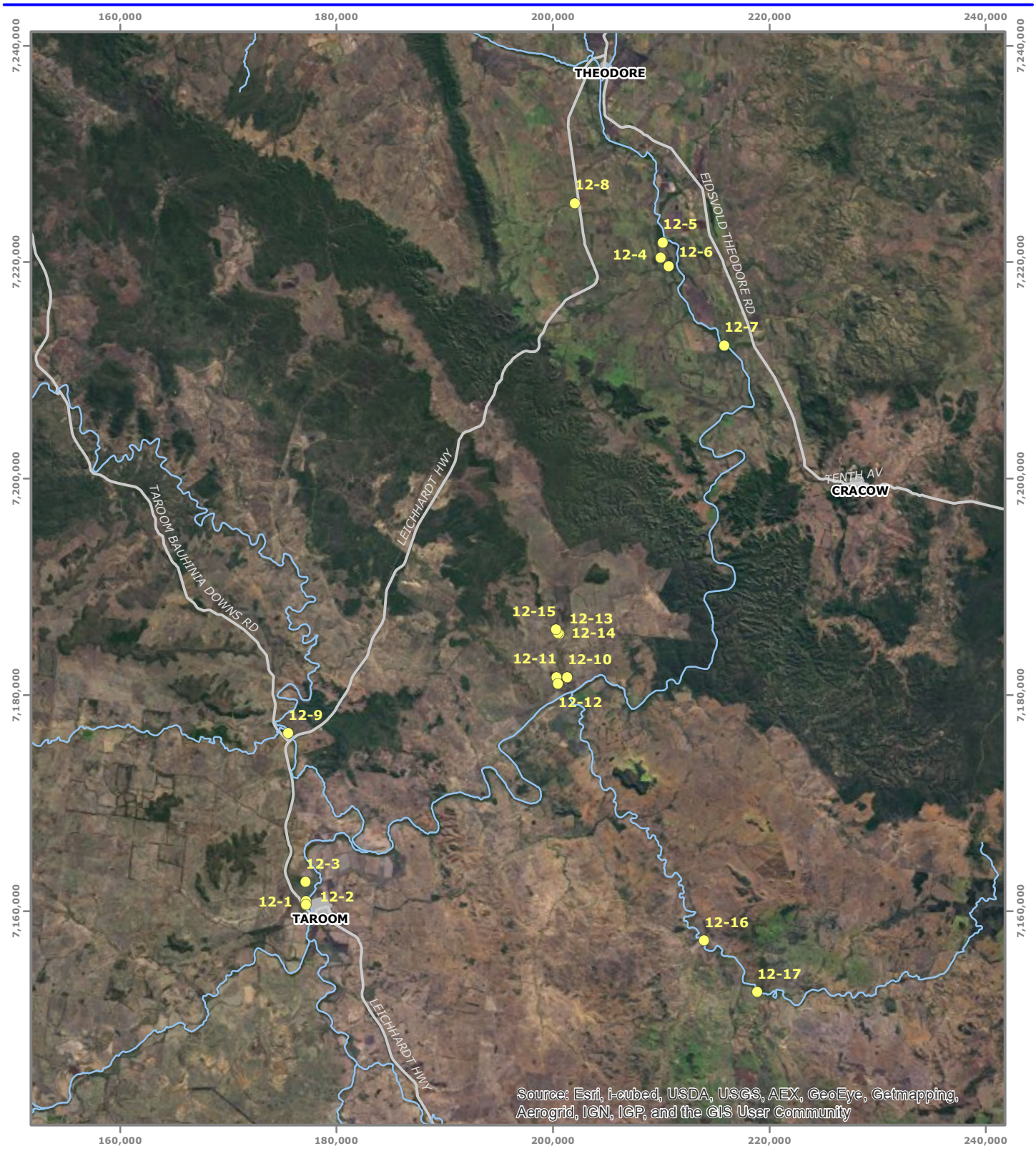
Survey Site	Habitat Patch	Historic Site Reference	Habitat Type	Photographs
Dawson Floodplain West	12-8	NA, new site	Ephemeral wetland fringed by Qld Blue Gum and other Eucalypt species 9km west of Dawson River on small unnamed watercourse.	
Palm Tree Creek	12-9	BS76, AD12 (Ingram and Stanisic 1997); Site 3, 27-28 (BAAM 2009); Ad1, Ad2, Ad3 (JKR Ecological 2011)	Open Forest of Carnarvon Palm on Palm Tree Creek. Carnarvon Palm dominates the upper strata of vegetation, with limited midstorey and degraded understorey due to grazing. Palm Tree Creek is sandy and heavily eroded at this location. Limited accumulation of palm fronds and other leaf litter due to recent flooding. Some piles of flood debris which accommodate common snail species.	

Survey Site	Habitat Patch	Historic Site Reference	Habitat Type	Photographs
Mt Rose	12-10	BM8, BS17 (Ingram and Stanisic 1997); Boggomoss 14 (BAAM 2009)	Mound Spring on Mt Rose. Station. Boggomoss No. 14 of previous investigations. Treed mound spring dominated by Qld Blue Gum with understorey of sandpaper fig.	
Mt Rose	12-11	BM17, BS 23 (Ingram and Stanisic 1997); Boggomoss 15 (BAAM 2009)	Mound Spring on Mt Rose. Station. Boggomoss No. 15 of previous investigations. Treed mound spring dominated by Qld Blue Gum.	

Survey Site	Habitat Patch	Historic Site Reference	Habitat Type	Photographs
Mt Rose	12-12	Boggomoss 16 (BAAM 2009)	Mound Spring on Mt Rose. Station. Boggomoss No. 16 of previous investigations. Treed mound spring dominated by Qld Blue Gum.	
Boggomoss Station	12-13	BS 27-30 (Ingram and Stanisic 1997); Sites 47-49 (BAAM 2009); Ad 5, Ad6, Ad7 (JKR Ecological 2011)	Mound Spring on Boggomoss Station, corresponding with Survey Site 47 of BAMM (2009). Permanently moist to wet conditions underfoot with deep leaf litter, abundant logs and well-developed fernland of Bungwall fern and associated sedge species. Sandpaper Figs present on margins of Spring. Evidence of relatively recent fire on margins of spring.	

Survey Site	Habitat Patch	Historic Site Reference	Habitat Type	Photographs
Boggomoss Station	12-14	BS 27-30 (Ingram and Stanisic 1997); Sites 47-49 (BAAM 2009); Ad 5, Ad6, Ad7 (JKR Ecological 2011)	Brigalow Woodland on Boggomoss Station, adjacent to Survey Site 47 of BAMM (2009). Well developed leaf litter and extensive woody debris available.	
Boggomoss Station	12-15	BS 27-30 (Ingram and Stanisic 1997); Sites 47-49 (BAAM 2009); Ad 5, Ad6, Ad7 (JKR Ecological 2011)	Mound Spring on Boggomoss Station, corresponding with Survey Site 48 of BAMM (2009). Permanently moist to wet conditions underfoot with deep leaf litter, abundant logs and well-developed fernland of Bungwall fern and associated sedge species. Sandpaper Figs present on margins of Spring.	

Survey Site	Habitat Patch	Historic Site Reference	Habitat Type	Photographs
Cockatoo Creek	12-16	NA, new site	Wetland Fringed by Blue Gum. Large ephemeral wetland on Cockatoo Creek Floodplain. Limited or no midstorey development and very sparse groundcover. Abundant logs on margins but no vegetative cover, reducing potential shelter sites. Evidence of stock impacts.	
Cockatoo Creek	12-17	NA, new site	Fringing Riparian Woodland on Cockatoo Creek Floodplain. Limited or no midstorey development and very sparse groundcover. Abundant logs on margins but no vegetative cover, reducing potential shelter sites. Evidence of stock impacts.	



Legend

- Survey Sites
- Watercourse
- Roads

Figure 1: Survey Site Locations

Nathan Dam, Survey for Boggomoss Snail

Map Number: 12032_01
Date: 19 November 2012
Map Projection: MGA94 (Zone 56)

0 2.5 5 10 15 20 25
Kilometers

N

ecological survey & management

2.3 Density surveys and population estimates

The current study sought to gather data pertaining to the density of snails within preferred habitat. Two methods were employed, Linear Transects and Random Quadrats.

2.3.1 Linear Transects

Linear transects were established within patches of habitat known to support live snails (that is, where a live snail was recorded via targeted active searching). As live snails were only recorded from two patches of habitat, only two survey transects were completed during 2012.

Consistent with previous studies, a 100 m transect (placed along the topographic contour gradient) was established, commencing at the location of the positively identified snail so as to include the presence of the snail within the overall transect result. It has since been recognised that this process leads to a likely over-estimation of the density however to allow direct comparison with earlier surveys, the technique is used here.

At every 5 m along the 100 m transect a 1 m by 1 m plot (giving a total search area of 20 m^2 per transect) was thoroughly searched, whether that plot contained potentially suitable habitat for the snail or not. This methodology accommodates the patchiness of suitable microhabitats for the species as search quadrats placed on a transect have an equal chance of including or excluding suitable microhabitats, and therefore are more likely to produce a realistic population density.

In order to test the influence of quadrat size on density estimates, in the instance that a snail was recorded, the quadrat size was expanded to 2m x 2m, then 3m x 3m, with the total number of snails recorded in the expanded area recorded. As two boggomoss snails were recorded, this was completed at two sites.

This approach allowed an analysis of the power associated with different sample unit sizes and degree of replication. It will also allow an analysis of our ability to stratify by suitable microhabitat. If the field estimate of “suitable microhabitat” appears to be realistic (that is, it does actually relate to where snails are found), then our estimate of the total available suitable microhabitat at a site can be better specified prior to extrapolating to estimate the total population at each site.

2.3.2 Randomly placed quadrats

As a comparative approach to the transect methodology described above, areas of known habitat (the same patches to be sampled using the transect methodology) were mapped as polygons using ArcGIS software via air photo interpretation completed by an experienced ecologist.

Within the GIS environment, an automated tool using a random point generation algorithm was used to generate 20 randomly assigned search quadrats within each of the habitat patches.

A series of 1m x 1m quadrats was sampled at those locations to give a total sample area consistent with the sample area used in transect surveys as described above. For example, if 1 transect was established which samples $20m^2$, a series of 20 randomly selected quadrats was completed within that patch.

2.3.3 Population Estimates

Under both sampling methodologies described above, a population estimate for each habitat patch was to be calculated by multiplying the average density of snails by the total area of the habitat patch. The standard error (SE) for the dataset was calculated and applied to the population estimate to give a population range.

This is effectively the simplest method of population estimation, whereby all of the individuals are counted in a manageable area (in this case, a quadrat) within the population's range, and this is assumed to represent the population density across the entire range. This is extrapolated to estimate the overall population size by the equation:

$$\text{Population Size} = Nc\ (Atot\ /Ac)$$

where, Nc is the number counted in the sample, Atot is the total area covered by the population, and Ac is the area covered by the sample.

2.4 Assessment of Flood related impacts at historic sites

In order to assess the impact of recent flooding on snail populations, historically occupied sites at Southend, Isla Delusion and Mt Rose were revisited.

Searches were completed in the first instance to confirm the continued occurrence of the species using the active search methods described above.

At each of these sites, notes were taken in relation to flood heights (as determined from water stains on tree trunks and the height of flood debris in trees), the duration of inundation (as ascertained from landholder discussions) and the amount of debris and its location. The river flow gauging record was also reviewed so that the recent floods could be put in context of historical floods.

3 Results

3.1 Limitations

The weather during field survey was suitable and snails were active. Rainfall was recorded in Taroom on 6 days between September 18 and 30 then again on 11 and 12 October.

At many sites microhabitats were limited or had been stripped due to flooding impacts. In addition, large piles of accumulated flood debris, which provided the only refugia, were difficult to search due to their compacted nature and mass of material to be shifted during search efforts.

3.2 Distribution surveys

Live Boggomoss Snails were recorded from only two survey sites in the current study, sites 12-5 (Nardoo) and 12-7 (Isla-Delusion Crossing) (Table 3). A single adult was recorded from each of these sites by the active search technique. Remnants of Boggomoss Snail shells were collected from Isla Delusion Crossing (1 sub-adult, recently deceased, shell opaque) and Mt. Rose Station Boggomoss 14 (20 old, calcified shells).

Table 2 - 2012 Survey effort and results, 2012

Survey Site	Habitat Patch	Search effort (person hours)	Live snails found	Dead snails found
Taroom Common	12-1	2	Nil	Nil
Taroom Common	12-1	2	Nil	Nil
Taroom Common	12-2	2	Nil	Nil
Taroom Common	12-3	3	Nil	Nil
Nardoo	12-4	6	1 adult	Nil
Nardoo	12-5	6	Nil	Nil
Southend	12-6	6	Nil	Nil
Isla-Delusion	12-7	25	1 adult	1 sub-adult
Dawson Floodplain West	12-8	10	Nil	Nil
Palm Tree Creek	12-9	2	Nil	Nil
Mt Rose	12-10	14	Nil	20 adults
Mt Rose	12-11	2	Nil	Nil
Mt Rose	12-12	1.5	Nil	Nil

Survey Site	Habitat Patch	Search effort (person hours)	Live snails found	Dead snails found
Boggomoss Station	12-13	3	Nil	Nil
Boggomoss Station	12-14	1	Nil	Nil
Boggomoss Station	12-15	2	Nil	Nil
Cockatoo Creek	12-16	2	Nil	Nil
Cockatoo Creek	12-17	85.5	Nil	Nil

The search effort expended at each site is generally reflective of the size of the patch and the availability of suitable microhabitat. As such, search effort for small patches of habitat, although lower in terms of search hours, are considered equally thorough to searches of larger habitat patches.

Plate 1 – Adult Boggomoss Snail, recorded from site 12-5 at Nardoo

3.3 Density surveys and population estimates

Both Boggomoss snails recorded during the current study were found in randomly placed 1m x 1m quadrats. The snail was then included within the first 1m x1m quadrat on a 100m transect (1 quadrat was placed every five metres for a total of 20 quadrats). As such, the density of Boggomoss snails observed within each patch was 1 snail per $20m^2$ or 25 snails per hectare.

The expanded quadrat technique recorded no further snails from the increased sample area and thus provided no further data to inform density or population estimates.

Other than the two snails recorded in randomly assigned quadrats, no further Boggomoss snails were recorded from density estimate surveys using either linear transects or randomly selected quadrats. T

Boggomoss snails were recorded at a density of 1 snail per $20m^2$ (250 snails per hectare). At these densities population estimates for Isla Delusion would be 3600 (2232-5832) snails, based on an area of 14.4ha of suitable habitat and 15,000 (9300-24,300) snails, based on approximately 60 hectares of potentially suitable habitat at Nardoo.

The standard error (SE) applied to the population estimate to give a population range indicates a low level of statistical certainty, primarily as a result of a very small sample size.

3.4 Availability of microhabitats

One 100m transect was established at each site where snails were recorded. The percentage cover of microhabitat considered suitable for the Boggomoss snail was recorded on each transect. Results were 26% (26 metres of intercept) for Nardoo and 61% for Isla Delusion.

3.5 Flood Impacts

Table 3 provides a summary of flood impacts (2010-11 floods) on the survey sites visited in 2012. **Appendix 1** shows photographs with flood heights indicated.

Table 3 - Summary of flood impacts at survey sites

Survey Site	Habitat Patch	2011 Flood Impacts
Taroom Common	12-1	Inundated to a depth of 2.5m, duration unknown. Leaf litter stripped although much flood debris present on the upstream side of trees.
	12-1	Inundated to a depth of 2.5m. Leaf litter stripped although much flood debris present on the upstream side of trees.

Survey Site	Habitat Patch	2011 Flood Impacts
	12-2	Inundated to a depth of 2.5m. Leaf litter stripped although much flood debris present on the upstream side of trees.
	12-3	Inundation to a depth of 2-3m for a period of 3-4 weeks. Some areas stripped of leaf litter but others with large mounds of accumulated palm fronds and debris deposited during flood events.
Nardoo	12-4	Inundation to a depth of 2-3m for a period of 3-4 weeks. Some areas stripped of leaf litter but others with large mounds of accumulated palm fronds and debris.
	12-5	Inundation to a depth of 2-3m for a period of 3-4 weeks. Stripped of accumulated leaf litter with only minor accumulation of flood debris.
Southend	12-6	Inundation to a depth of 1.5m, duration unknown. Some areas stripped of leaf litter but others with large mounds of accumulated palm fronds and debris, unaffected by recent flood events.
Isla-Delusion	12-7	Not known to have been inundated.
Dawson Floodplain West	12-8	Inundated to a depth of 2.5m, duration unknown. Some areas stripped of leaf litter but others with large mounds of accumulated palm fronds and debris.
Palm Tree Creek	12-9	Inundation to a depth of 1.5m, duration unknown. Some areas stripped of leaf litter but others with large mounds of accumulated palm fronds and debris, unaffected by recent flood events.
Mt Rose	12-10	Inundated to a depth of 1.5m for a period of 4-5 weeks. Limited leaf litter accumulation, logs relatively abundant.
Mt Rose	12-11	Inundated to a depth of 2m for a period of 4-5 weeks. Edge of mound spring stripped of logs, debris and leaf litter.
Mt Rose	12-12	Inundated to a depth of 2m for a period of 4-5 weeks. Edge of mound spring stripped of logs, debris and leaf litter.
Boggomoss Station	12-13	Not known to have been inundated.
Boggomoss Station	12-14	Not known to have been inundated.

Survey Site	Habitat Patch	2011 Flood Impacts
Boggomoss Station	12-15	Not known to have been inundated for an extended period.
Cockatoo Creek	12-16	Not known to have been inundated for an extended period.
Cockatoo Creek	12-17	Not known to have been inundated for an extended period.

4 Discussion

4.1 Snail distribution

Surveys were undertaken at five sites from which live snails had been historically recorded but they were found at only one (Isla Delusion). The three mound springs surveyed on Mt Rose Station failed to yield any live snails. Boggomosses 15 and 16 have now been re-surveyed twice since snails were originally found there with no further evidence of their existence being recorded. For these sites the survey effort is considered thorough and given the lack of suitable habitat (as a result of flood impacts; Section 4.4) it is considered that the snail no longer exists here.

Boggomoss 14 is the historic Mt Rose site and has traditionally been regarded as a significant population centre. The survey effort is considered thorough and given that Dr John Stanisic also failed to find any live snails here despite 11 hours searching in April 2012, the continued existence of a sustainable population of the species at the site is unlikely.

Live snails were only found downstream from the proposed Nathan Dam direct impact area during the current study. Despite 43.5 hours of intense searching, no live snails were found within or upstream of the impact area.

The known distribution of the Boggomoss snail was not expanded by the current study and the species is known to reach its southwestern distributional limits at Mt Rose Station, and northern distributional limits at Kia Ora near Theodore.

4.2 Density surveys and population estimates

No live or dead snails were found at any of the six new sites investigated upstream of the inundation area.

There has also been a marked decline in the number of live snails recorded from all known sites between 2009 and 2012 (see **Appendix 2** for historical data). For example, searches at Isla-Delusion by SKM (2009) recorded 8 live snails in 14 person hours of searching (0.57 snails per person hour) whilst this survey recorded 1 snail in 25 person hours of active searching (0.04 snails per person hour).

Similarly, at Mt Rose Boggomoss 14, BAAM (2009) recorded 22 live snails in 12 hours of searching (1.83 snails per person hour), but no live snails were recorded in 25 person hours of searching at the same site in 2012 (comprising Dr Stanisic's time in April plus that in this study). There were many dead snails returned at Mt Rose in all studies completed to date, but no recently deceased snails (as judged by transparency of shells) were recorded during this study.

The decline in return for effort is marked and is interpreted as real given the experience of the staff and the effort employed.

4.3 Availability of microhabitats

Microhabitat cover was recorded from two transects. Results were 26% (26 metres of intercept) for Nardoo and 61% for Isla Delusion. As these data have only been recorded from two sites within two patches, no meaningful comparison between sites or between occupied and nopn-occupied habitat patches is possible.

4.4 Impacts of Flooding

The majority of habitat known to be occupied by the Boggomoss snail was impacted by consecutive floods in March 2010, December 2010 and January 2011. These floods events, and in particular the December 2010 event, are significant in a historical context, with only two larger events on record, both from pre 1900 (1870 and 1890).

In terms of the BoM classifications, the December 2010 flood at Taroom was considered "major", as is any flood above 7 m on the flood gauge. A 7 m flood is roughly equivalent to a 1 in 10 AEP event, that is, the flood has a 10% probability of being equalled or exceeded in any given year. Above a gauge height of 7.6 m houses in Taroom begin to be affected by floodwaters (BoM 2011). A flood of this size has a probability of approximately 1 in 20 AEP, or 5% of occurring in any given year.

The December 2010 flood at Taroom is considered to be approximately equivalent to a 1 in 440 AEP and is considered to be a very rare event, with a low probability of occurrence (0.2% in any given year) (DSITIA 2012). However, there is considerable uncertainty around the probability of the event, and the 90% confidence limits on the estimate range from 1 in 100 AEP to 1 in 4500 AEP (DSITIA 2012).

From the available information, it appears that there have been no fires, no additional land clearing and essentially no change to the land management regimes at any of the known sites for the species between 2008 and 2012. As such, the cause of apparent decline in snail numbers is considered most likely to be related to consecutive flood events, which impact both individual snail survivorship and the availability of suitable microhabitat.

The January 2011 floods on the Dawson River were the largest floods since the 1800's. Historically the Boggomoss Snail is likely to have occurred patchily across the Dawson Floodplain in a variety of habitat types. Connectivity between these patches would have been reasonably high, or at least much higher than the present day, giving opportunities for movement of snails between occupied patches.

Transport via floods has also been suggested such that if the animals survived the transport and were deposited at a patch of suitable habitat they may be able to establish a population. This can obviously only occur in a downstream direction.

The most upstream known habitat for the species is restricted to three mound springs on Mt Rose Station. These have been reduced to tiny areas of suitable habitat within a hostile matrix of cultivated land and unsuitable, drier habitat types.

Snails are very unlikely to disperse of their own volition between individual mound springs across cultivated land and each mound spring essentially represents an island of habitat. Thus, populations of the species on these isolated mound springs are highly vulnerable to one-off stochastic events and subsequently to local extinction. The floods of recent years appear to have removed most if not all of the snails from these sites and the results from downstream sites do not suggest any snails survived flood transport to successfully colonise those sites.

As the Mt Rose sites are the most upstream, the chance of natural recolonisation of these sites is negligible.

5 Summary and Recommendations

5.1 Summary

Surveys for the species in 2012 focussed on sites which were historically known to support the species, as reported in various studies between 2009 and 2011.

No live specimens of the species were recorded from Mt Rose Station or Southend, two sites at which the snail was readily recorded in previous studies. Only two live individuals of the species were recorded in 2012, both from habitats downstream of Isla-Delusion Crossing (one adult snail within Isla Delusion and one adult snail on Nardoo).

Attempts to clarify population estimates and to experiment with survey design were unsuccessful due to a failure to record more that a single Boggomoss Snail on any population density transects or within randomly assigned quadrats. Population density was observed at 250 snails per hectare at Isla Delusion and Nardoo.

At the observed densities, population estimates for Isla Delusion would be 3600 snails, based on an area of 14.4ha of suitable habitat and 15,000 snails, based on approximately 60 hectares of potentially suitable habitat at Nardoo.

The results of the current survey suggest that the density of Boggomoss Snails has declined markedly at all known sites and this is best represented by declining returns (in terms of live snails recorded per person hour of searching) for search effort.

A total of 18 sites are known to either currently support, or to have historically supported the species. Only one of these sites (Mt Rose Station) has the potential to be impacted by the Nathan Dam Project.

5.2 Recommendations

No live Boggomoss Snails have been recorded from the Nathan Dam project area since 2008, and the status of the species in the vicinity of Mt Rose Station requires further intensive investigation to determine whether the species persists at that location.

6 References

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Appendix 1 – Photographs of flood inundation heights and impacts, known sites

Plate 1a – Southend, typical leaf litter post flood

Plate 1b - Southend, typical leaf litter pre flood

Plate 1b: Southend – height of flood inundation, note lack of leaf litter

Plate 1c: Isla-Delusion – height of flood debris

Plate 1d: Mt Rose Boggomoss No. 16 – Margins of habitat stripped of leaf litter and debris

Plate 1e: Nardoo - height of flood inundation, western extent of habitat patch

Appendix 2 – Results of all field surveys 2009-2012

Regional Location	Property Name / Site	Site Reference Number	Coordinates	Survey: Organisation (Year)	Survey Intensiveness (person hours)	Adult	Sub-Adult	Juvenile	Total (live)	Adult (dead)	Sub-Adult (dead)	Juvenile (dead)	Total (dead)	Total (combined)
Theodore	Dawson River Anabranch (Leichhardt Highway - near weir)	VH2	TBC	SKM (2009)	1				0	1			1	1
Kia Ora	Kia Ora (Leichardt Highway)	DF35	S:25°01'32.7" E:150°07'14.3"	SKM (2009)	1				0	2			2	2
	Kia Ora (Leichardt Highway)	DF36	S:25°01'16.5" E:150°07'01.7"	SKM (2009)	2	1		1	2	2			2	4
	Kia Ora (Dawson River)	DF37	S:25°01'17.4" E:150°06'47.5"	SKM (2009)	1	1			1				0	1
Nardoo	Carnarvon Palm Woodland	12-5	S: 25°5'29.6", E: 150°7'38.7"	ECOSM (2012)	6	1			1				0	1
Southend	Southend	D14	S: 25°7'34.5", E: 150°8'13.2"	SKM (2009)	2	2	4		6	12			12	18
	Southend (northern portion)	D15	S: 25°07'01.9" E: 150°08'27.6"	SKM (2009)	1	1			1				0	1
	Southend (northern portion)	D16	S: 25°06'42.5" E: 150°08'18.9"	SKM (2009)	1	1			1	3			3	4
	Southend	VH24	S: 25°7'34.5", E: 150°8'13.2"	SKM (2009)	2			2 (H)	2	5			5	5
	Southend	VH25	S: 25°7'9.06", E: 150°8'34.3"	SKM (2009)	1	2			2	2			2	4
	Anabranch of Dawson River on Southend	Ad9	S: 25°6'54.12", E: 150°7'40.7"	JKR (2010)	4	1			1				0	1
	Southend (ephemeral wetland)	Ss12	S: 25°6'51.6", E: 150°7'57.8"	JKR (2010)	4	5	1		6	2	2		4	10
South of South End		D13	S: 25°08'21.5" E: 150°08'35.2"	SKM (2009)	1				0	1	1		2	2
		JR16	S: 25°09'03", E: 150°09'08"	SKM (2009)	1	1			1				0	1
Isla Delusion	Dawson River crossing on the Isla-Delusion Rd: Known Boggomoss Snail locality	11	S: 25°10'52.1394", E: 150°11'0.1674"	Ingram and Stanisic (1997)	4	2	4		6		4		4	10
	Dawson River environs upstream of stock and camping reserve	8	S: 25°12'29.16", E: 150°12'9.3594"	BAAM (2009)	90		1		1		4		4	5
	Dawson River crossing on the Isla-Delusion Rd: Known Boggomoss Snail locality	11	S: 25°10'52.1394", E: 150°11'0.1674"	BAAM (2009)	16		3		3				0	3
	Isla Delusion: Livistona woodland on Dawson River	JR18	S: 25°10'31", E: 150°10'42"	SKM (2009)	1	2	1		3	5			5	8
	Isla Delusion: Livistona nitida woodland on anabranch of Dawson River	JR19	S: 25°05'38" E: 150°09'07" (TBC)	SKM (2009)	14	8			8	13			13	21
	Isla-Delusion Crossing	12-7	S: 25°10'27", E: 150°10'37.3"	ECOSM (2012)	25	1			1		1		1	2
	Isla-Delusion camping reserve	Not stated	Unkown	BAAM (2012)	6	0	0	0	0	0	0	0	0	0
Gyranda Weir	Gyranda (east bank)	D2	S: 25°18'07.5" E: 150°09'46.8"	SKM (2009)	1				0	1			1	1
	Gyranda (west bank)	D3	S: 25°18'27.6" E: 150°09'35.1"	SKM (2009)	1				0	2			2	2
	Gyranda (west bank)	D4	S: 25°18'55.7" E: 150°10'12.2"	SKM (2009)	2	1			1	3			3	4
	Gyranda (east bank north of weir)	D5	S: 25°16'14.8" E: 150°10'27.6"	SKM (2009)	1				0	1			1	1
Nathan Gorge	Nathan Gorge (Cabbagetree Creek)	D11	S: 25°42'83.6" E: 150°17'07.9"	SKM (2009)	1	3	1		4	2			2	6
		Not stated	Unkown	BAAM (2012)	1	0	0	0	0	0	0	0	0	0
Mt Rose Boggomoss		14	S: 25°27'8.4594", E: 150°1'42.528"	Ingram and Stanisic (1997)	20	2	10		12	2	45	7	54	66
		14	S: 25°27'8.4594", E: 150°1'42.528"	BAAM (2009)	12		2	20	22	41	130	38	209	231
		15	S: 25°27'7.92", E: 150°1'14.88"	BAAM (2009)	4		1	2	3				0	3
		16	S: 25°27'22.6794", E: 150°1'16.3194"	BAAM (2009)	4		2	2	4				0	4
		12-10	S: 25°27'8.4594", E: 150°1'42.528"	ECOSM (2012)	14				0	20			20	20
		Not stated	Unkown	BAAM (2012)	13	0	0	0	0	80	0	0	80	80
20km (approx) south of Mt Rose Boggomoss	Tributary of the Dawson River located upstream of the proposed dam wall.	5	S: 25°34'3.864", E: 150°4'15.5634"	Ingram and Stanisic (1997)	4				0		1		1	1
Total					**262**	35	30	25	**92**	200	188	45	**433**	**523**

H - Hatchling