PART B – AEIS

28. MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

28.1. Listed threatened species and communities

28.1.1. Communities or species listed since the project was declared a controlled action

Coolabah Black Box woodland, Koala and White Throated Snapping turtle were listed as threatened after the proposed action was determined to be a Controlled Action so in accordance with Section 158A of the EPBC Act, are not required to be included in the assessment.

28.1.2. Boggomoss Snail

28.1.2.1. Justification of sampling methodology and estimates of population size

A number of submissions questioned the estimates of population size based on the EIS surveys completed by SKM (2009) and JKR Ecological (2010). In those studies, the boggomoss snail was found in a number of sub-populations and the population summed across those sub-populations was significantly higher than population estimates made prior to the preparation of the EIS. The EIS noted that the most important result from the field surveys was that the species was confirmed as being far more widely distributed than first thought (Section 28.3.4.2 of the EIS). The exact size of the population/s was thought of secondary importance to this information on its distribution given the criteria for assessment of significant impacts.

The Significant Impact Guidelines for Critically Endangered species (DEWHA 2013, reproduced below), upon which EIS assessments are made, does not require an estimate of the entire population of a species throughout its range or of the relative sizes of any sub-populations. The guidelines require an understanding of how many populations exist and this was the principal purpose of the EIS surveys undertaken. The single criterion that incorporates the concept of the size of a population (the first criterion), does not actually require an estimate of the size of the population in order to answer the question.

Lead to a long-term decrease in the size of a population of a species?

Reduce the area of occupancy of the species?

Fragment an existing population into two or more populations?

Adversely affect habitat critical to the survival of a species?

Disrupt the breeding cycle of a population?

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?

Introduce disease that may cause the species to decline?

Interfere with the recovery of the species?

The criteria require knowledge of the area of occupancy and the number of populations (or sub-populations), which are matters of distribution, not abundance. They require knowledge of habitat, which is again not population related (though population density at a site can be an indicator of habitat suitability). EIS surveys were specifically directed at addressing these issues.

Similarly the listing advice for the species prepared by the Threatened Species Scientific Committee did not recommend listing on the criterion of population size alone but on geographic distribution and decline in numbers, the latter inferred from the extent of land clearing. The advice repeatedly referred to the risk related to the fact that the species was only known from two sites and that the likelihood of it being found elsewhere was low. Hence SunWater focussed its efforts on determining if these assumptions were correct.

As the validity of population estimates have been questioned, a response is provided below. Historical population estimates have been:

- Stanisic (2008 in the Recovery Plan)): Mt Rose <100; Isla Delusion <500;
- BAAM (2009, led by Dr Stanisic): Mt Rose >350; Isla Delusion – too few captures to allow an estimate;
- SKM (2009): 11,497 – 23,323 across four locations not including Mt Rose; and
- JKR (2010): 26,169 – 36,479 across six locations not including Mt Rose.

An independent peer reviewer was appointed by the Coordinator-General's office to review population estimates to date (BAAM 2009 and later) and concluded that on statistical grounds none of the estimates were valid. The main reason was that initial sample sites were chosen because they had been predetermined as likely to contain the species and hence were biased. Each method was also determined as invalid for a number of statistical reasons though these were not the reasons raised in submissions. Hence those submissions are addressed below. The independent peer reviewer also reviewed a draft of this section and his conclusions are reported at the end of the section.

Estimating the population at a site was defined as "difficult" within the Recovery Plan (Stanisic, 2008) predominantly owing to the limited understanding of the complex nature of the microhabitat in which the snail lives. Despite this, broad estimations of populations were provided in the Plan without a detailed methodology which could allow replication.

BAAM (2009), led by Dr Stanisic, used a micro-habitat approach wherein searching took place under certain tree species (including Sandpaper Figs), thought by Dr Stanisic to be a determinant of distribution, and the estimate of the density of snails per micro-habitat was multiplied by the number of such habitats at a site. The method was only used at one site, Mt Rose.

SKM (2009) and later JKR (2010) (led by Jason Richard on both occasions) used a plot on transect approach at a number of sites wherein once a snail was found at a site, a transect was established and sampling took place in 10 equal sized plots equally spaced along the transect. The snail density (snails/m^2) so obtained was multiplied by the estimated area of similar habitat at the site in order to estimate the population at the site.

As in most field sampling exercises it is not physically possible to search all the available habitat, so a subsampling approach is required. The issues raised in submissions are largely related to how that subsampling is undertaken and then how the subsample result is extrapolated to provide an estimate of the population. In this case because sampling was undertaken at relatively discrete habitat patches, how the population within the patches is summed to estimate the overall population is also relevant.

A submitter suggested that the micro-habitat method should form the preferred basis for survey and subsequent estimation of populations. At the start of the Project, SunWater did not favour this method because the knowledge base available at the time was limited, so to move directly to this level of targeted searching was considered premature. As an example, information available from previous surveys did not show firm evidence of any clear association with particular tree species (for example, Sandpaper Fig).

JKR (2010) reported specific testing of this assumption and of the 38 live snails found by SKM or JKR, not one was under a Sandpaper Fig. The snail clearly has a broader association with deep moist litter almost irrespective of the tree species present. This result provided clear support for SunWater's approach with respect to not assuming an association with particular micro-habitats.

SunWater preferred an approach which was replicable, did not rely on subjectivity and had a sound scientific basis. In determining an appropriate procedure, SunWater requested SKM to comprehensively review literature on snail sampling to determine what methods had been used in other studies. As documented in Section 4.2.1 of Appendix 11D (EIS), reports in the scientific literature on snail sampling techniques are limited. A recent reference had used randomly assigned plots of uniform size and the population was estimated by multiplying the average plot density by the assumed distribution area. Moving to a plot-on-transect approach rather than random plots in order to produce the plot density is in accord with common ecological sampling procedures (Zar 2010, Sutherland 2006).

A submitter referred to the survey methodology employed by SKM and JKR as "sound". That is, the various survey teams were all likely to find the snail if it was present in a quadrat or under the tree being sampled. This statement can be supported by a comparison of the density of snails per square metre based on the micro-habitat method conducted by BAAM at Mt Rose (366 individuals over 7,500 m^2 = 0.05 snails/m^2) and that for the various sites examined by SKM and JKR (range 0.02 to 0.30 snails/m^2). What this comparison suggests is that the historic density of snails at Mt Rose was not exceptional and is within the range estimated from a number of other sites irrespective of the method used or the team undertaking the survey.

Using the plot-on-transect approach, the resultant snail density within each habitat patch is multiplied by an estimate of available habitat area in that patch to estimate the size of the patch population. A submitter criticised this approach on the basis that it assumes "the snail density is homogenous within its distribution area". This interpretation is partly correct, in that density is assumed to be uniform within each habitat patch but not over the total distribution area. However, the interpretation is incorrect because the distribution area as represented within the plots takes into account both suitable and unsuitable habitat. Similarly the density is assumed homogenous or uniform simply for the purpose of extrapolating from a subsample to the full patch area; this should not be confused with any assumption regarding the spatial distribution of the snails, which all parties agree is patchy. The method employed as part of the BAAM survey (2009) makes the same assumption as that criticised but it does so in relation to the sampled micro-habitats and the available micro-habitats. Under the BAAM methodology, 6 micro-habitat sites were sampled (selected on the basis that they contained Sandpaper Figs), an average density of snails per micro-habitat site was determined then multiplied up by the number of sites considered to contain similar habitat (Sandpaper Figs and large gum trees as determined from an aerial photograph; Figure 4.1 BAAM 2009). In order to perform that extrapolation it must be assumed that density is homogenous across all the micro-habitats included in the extrapolation so in this respect it is no different to the method employed by SKM or JKR.

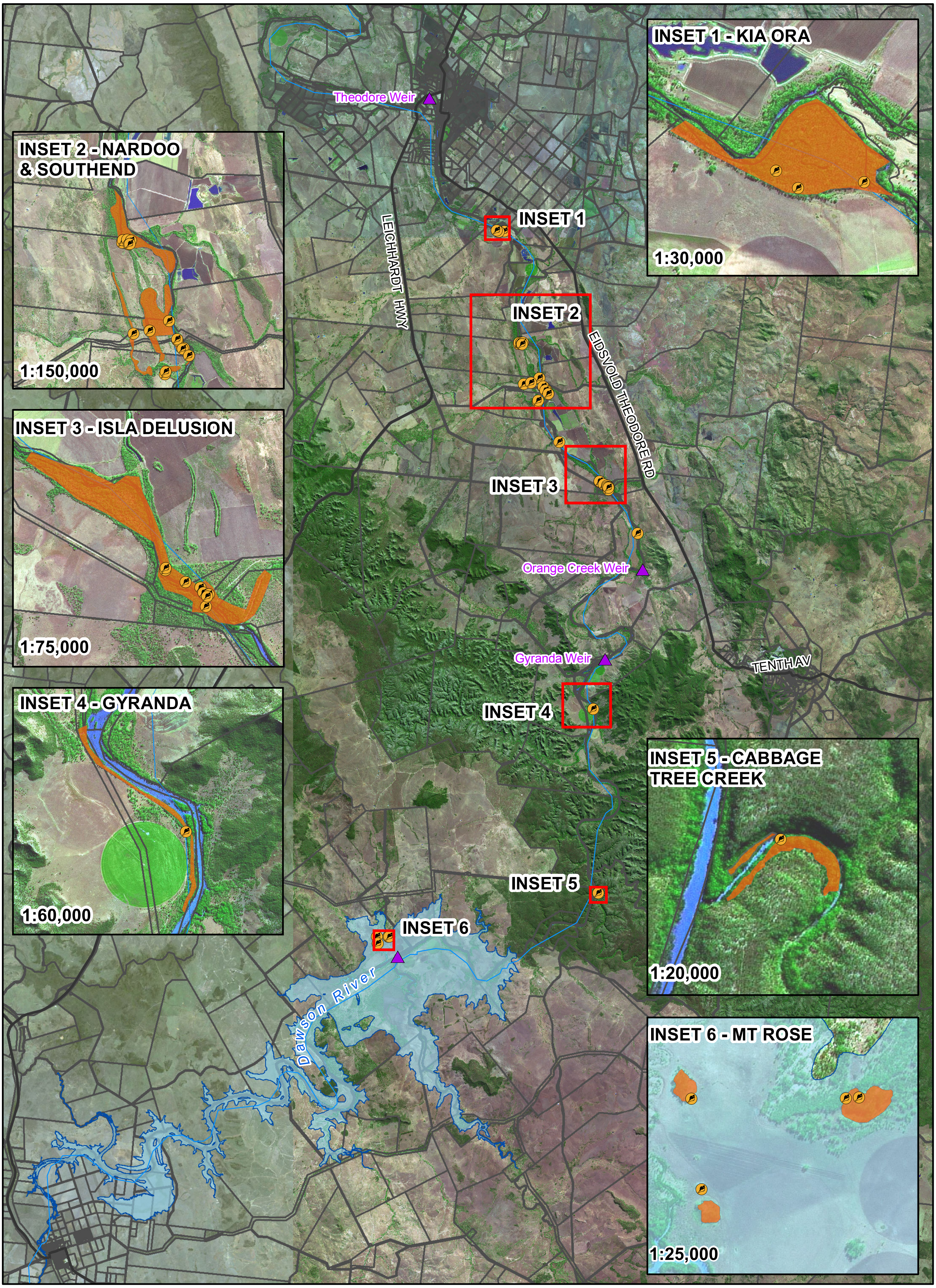
Similarly if one were to target sampling areas of suitable "deep moist litter", how would such areas be delineated? This would require subjective assessment in the field. Mapping of all the "deep moist litter" in a habitat area would be required in order to allow the necessary extrapolation from sampled area to total habitat area and again the assumption of homogenous density across all areas of deep moist litter would need to be employed.

A submitter considered it inappropriate to extrapolate the plot-on-transect results to "the entire riparian habitat area". The Recovery Plan (Stanisic 2008, Section 3.2, underline added) stated "it is thought that the entire alluvial flat ecosystem was once the snail's preferred habitat". However SunWater, SKM and JKR did not undertake that level of extrapolation. A critical step in the extrapolation process is the estimate of the total available habitat within each patch. The mapping of potentially suitable habitat by SKM and JKR was based on a combination of aerial photography, vegetation mapping (Regional Ecosystems) and confirmation via field survey (where possible) such that only areas of vegetation types known to support the snail, in good condition and close to the river were included (Sections 2.4.1 and 3.3.2 of SKM 2009, and section 4.4.2 of JKR 2010).

The approach used to estimate populations was intentionally conservative as was stated on page 28-44 of the EIS (with further clarification in brackets):

- Not including habitat more than 50 m from the river (despite snails being found beyond this distance).
- Not including areas of potential habitat that had not been physically investigated (substantial areas of potential habitat exist but were not sampled due to access constraints).
- Not producing estimates from small areas of habitat even if the snail was found there (live snails were found at 17 sites but population estimates were only made for 6 sites).
- Only using live snails.

Figure 28-1 shows that many areas of what would appear to be suitable habitat were not included in the population estimates. This is a clear example of how the extrapolation from the density measured by field sampling was undertaken in a conservative manner to produce the estimate of the population.



LEGEND

- Live Snails
- Weir
- Watercourse
- Main Roads
- Snail Habitat Area
- Full Supply Level (183.5 m AHD)

Figure 28-1

Projection: GDA94 Zone 56

0 1 2 4 6
Kilometres

Scale 1:340,000 (at A4)

N

SKM SunWater Making Water Work

ADDITIONAL INFORMATION TO THE NATHAN DAM EIS

Locations at Which the Boggomoss Snail Has BeenFound

In confirming the conservative approach employed by SKM and JKR, it should be noted that previous estimates (Stanisic 2008, BAAM 2009) of the area of just the two original habitat patches (Mt Rose and Isla Delusion Road crossing) were 43.8 and 45.25 ha respectively whereas the total area used by JKR (2010; Tables 2-4 and Table 28-10 of the EIS) across six sites was approximately 38.59 ha.

The conservative assessment used by SKM and JKR was then consistently applied to other stages of the impact assessment. For example, Table 28-22 of the EIS presented the proportion of known snail habitat which would be lost to inundation as 1.93% but this figure only used the patch sizes for which population estimates were made, not the area of all sites at which live snails had been found or the total potential habitat area. It also used a larger area for the impacted site at Mt Rose (0.75 ha) than presented in the Recovery Plan (0.5 ha). The most recent estimate of the area of potential habitat within the six core sites of known occupancy is over 449 ha (**Figure 28-1**).

A submitter suggested that the population numbers as presented in the EIS may "serve to diminish conservation measures for the species" and that it could "affect the application of long-term monitoring programmes that may need to form part of any relocation strategy". Both the population estimates and the relocation plan with its associated monitoring program (as designed for SunWater by BAAM 2011) were included in the EIS. It is therefore considered that the population estimates as presented in the EIS did not affect conservation measures or monitoring initiatives for the species.

A submitter also referred to a survey for the snail that was conducted in April 2012 (by Dr Stanisic for BAAM, 2012). The survey report was appended to two other submissions. The timing of the surveys did not accord with the recommendations of the Recovery Plan (Stanisic 2008), being September to February or "in early spring and late summer, preferably after rain". Conditions during the April 2012 survey were described as dry and Taroom snails were described as "in a state of heavy aestivation". Other historic surveys (e.g. SKM 2009) have also been conducted outside of the preferred period but active snails were found at those times.

A submitter stated that the survey "reinforced the conclusions drawn from BAAM surveys, viz., that there is a robust but small population on the Mt Rose site". This is not an accurate reflection of the April 2012 survey results. For example, the survey report did not use the word "robust" nor did it actually estimate population size. The report stated that the findings indicate "the likely presence of a viable population" however, as no live snails in any age class were recorded at either Mt Rose or Isla Delusion even the "likely presence" is questionable and there is certainly no basis for referring to any population as "robust".

The survey report (BAAM, 2012) states that the lack of live snails at Isla Delusion or Cabbage Tree Creek "is in direct contrast to a figure of 18,500 living individuals based on a report by SKM". Firstly, the SKM report did not provide a population estimate for Cabbage Tree Creek and the estimate for Isla Delusion/ Lagoona (Table 2 of SKM 2009) was 11,519 (standard error 8,844 – 14,193). Comparisons such as that made in the survey report are only valid should an assumption be adopted that the population remained static over the sampling period (2009 for SKM and 2012 for BAAM). Given the intervening significant flood events it is likely that populations present in 2009 had been substantially reduced so a direct comparison cannot be considered valid. Similarly, if the density of snails at this site was still the same as reported by SKM (2009) for Isla Delusion (approximately 1 snail per 12.5 m^2 of habitat), then within the 6 hours of searching allocated in April 2012 only a very low number of snails would ever have been expected. In fact if the results of the six pre-flood surveys are combined

(Ingram and Stanisic 1997, BAAM 2009 (x2), SKM 2009 (x2)) some 125 hours were spent searching and some 21 snails were found in total, an average of 5.95 hours searching per snail. The survey result is therefore consistent with historic results at this location.

The survey report (BAAM, 2012) attributes the result of no live Boggomoss Snails being found at any site to the dry conditions and the aestivation of the snails. No discussion is included to suggest that populations may have changed (declined) or that such a change may be linked to the 2010/11 floods. Given the historic recognition of the risks associated with floods and the very large size of these floods across suitable habitat, consideration of such events and the subsequent impacts would have been expected. EcoSM (2013) spent 25 hours searching the Isla Delusion site in spring 2012 when there was light rain and the snails were active. They found one live boggomoss snail at Isla Delusion and none at Mt Rose and suggested the result was likely linked to the 2011 floods.

The survey report suggested that an explanation for not finding the species at Mt Rose was that snails were probably aestivating under large logs, though the habitat was not searched. The potential for logs to serve as habitat is nominated a number of times in the Recovery Plan while the BAAM report (2009) refers to it as a "fact" that adults in particular prefer sheltering under large logs though again the habitat was not actually searched. Amec (2013) specifically searched 2316 micro-habitats, including large logs up to the size that the field team could lift by hand, and despite sampling 283 logs, of which 155 were on Mt Rose, found no adult snails under the logs and only 2 sub-adults in this habitat in total. In contrast, 36 adult snails were recorded under palm fronds, two under other forms of leaf litter and one in flood debris. It is possible that snails could move to the log habitat for the purpose of aestivation but this has not been tested. Of interest also from the Amec (2013) survey is that of the 152 snails of all age classes found at the time, 146 were under palm fronds.

The survey report (BAAM 2012) states "in line with the Recovery Plan for the Boggomoss Snail (Stanisic 2008), the large number of dead shells recovered is to be considered evidence of a living population". No such statement is included in the Recovery Plan. Section 2.3 of the Plan states that living populations are known from two sites but a dead shell was recorded from a third and at this site the status of the population was referred to as "possible". An alternative explanation for the lack of live snails observed during the April surveys which is not discussed in the report could be that the snails are dead. It is difficult to agree that dead snails can be used as evidence of a living population. At best, if the shells could be determined as recently deceased then it could indicate, as per the Recovery Plan, a possible living population. As noted above with respect to the conservative nature of the JKR population estimates, dead shells were not incorporated within population estimates presented in the EIS. Similarly Amec (2013) only counted recently dead snails (as recorded in Appendix 1 of Amec (2013)) but did record the presence of older shells (which they presented on the figures in the report).

A submission suggested that the relative lack of dead shells at Isla Delusion is indicative of an itinerant population, but another plausible conclusion could be that the shells are washed away during flood events, which is what is assumed to happen to the accumulated leaf litter at the site. In such a circumstance the lack of shells is essentially irrelevant to the status of the local population. Similarly as a dead shell could have been washed by floods from upstream or redistributed from a suitable patch in the same area (when the snail was either alive or dead), to be conservative its presence at the site where it was found should not be regarded as evidence that the site supports a living population or even represents suitable habitat for the species; it is simply where the floods left it. This was the approach adopted by SKM and JKR.

A submitter suggested that the figures returned by the April 2012 survey are in the same general proportion as earlier surveys. To clarify, the April 2012 survey was the only one up to that time to return a result of no live snails from both Mt Rose and Isla Delusion and as such the result is quite different to all previous results.

Tables 2-4 of JKR (2010) used various historic estimates of snail density and habitat patch area to estimate local population sizes. Mt Rose had not been surveyed using the plot-on-transect method so no alteration to the estimate of BAAM (2009; 350 snails) was made. As this was simply a comparative exercise using different snail densities, it can be used to show how relatively important the Mt Rose site may be based on possible population sizes. As noted above the density of snails at Mt Rose was within the range estimated at other sites so in terms of total population estimates per site, it is the area of estimated suitable habitat at a site which is important. The patch of habitat at Boggomoss 14 on Mt Rose is discrete so its area is easily delineated (0.75 ha or 7500 m^2). As the patch size at Mt Rose is relatively small (others have been estimated at up to 167 ha), its contribution to the overall population is unlikely to be high. The listing advice for the species repeatedly refers to this site as “the smaller population” of the then known two sites.

28.1.2.2. Impacts of floods since previous surveys

Major floods affected the Dawson River in 2010/11. **Figure 28-2** puts those floods in context with recent history.

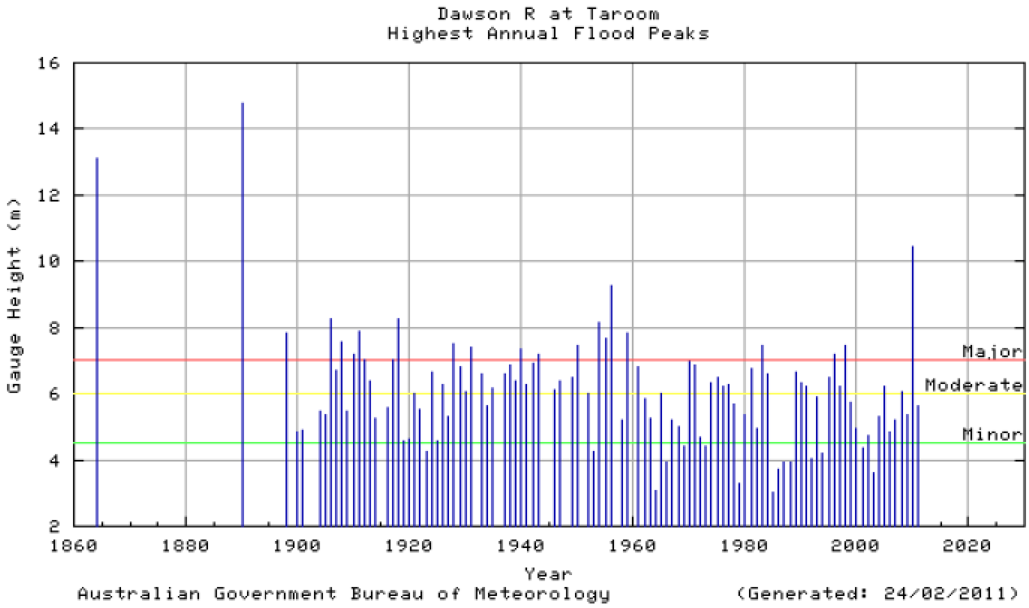


Figure 28-2 Highest annual flood peaks for the Dawson River at Taroom (BoM, 2011c)

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. Gauge heights peaked at over 7 m on several occasions in December 2010. A gauge height of 10.43 m was recorded on 29 December 2010, representing the peak of the 2010/2011 flood event.

The 2010/11 floods are significant in a historical context, with only two larger events on record, both from pre 1900 (1870 and 1890). Other major events occurred in 1956 (over 9 m), 1954, 1918, 1906 (over 8 m), 1998, 1983, 1959, 1953, 1952, 1948, and 1911 (over 7 m).

Historical water level data covering the period 1920 to 2013 at three flow gauges (130303A, 130303B and 130338A) near Glebe Weir record 10 flood events that would have inundated Boggomoss 14 (176.27 m AHD), with an average duration of three days per event. The average interval between flood events with volumes large enough to inundate Boggomoss No. 14 is 9.3 years.

Field surveys were completed by a team of scientists from SKM and EcoSM (formerly known as JKR) between 8 October and 13 October 2012. The weather suited snail surveys and snails were active. Rainfall was recorded in Taroom on 6 days between September 18 and 30 then again on 11 and 12 October. The report (EcoSM, 2013) is provided as **Appendix B28-A**. The key result of the survey was that despite intensive searching, no live snails were found at any site on Mt Rose, one live snail was found at Isla Delusion and one live snail was found at a new site at Nardoo, which is near Southend. Nardoo had not previously been accessible for snail surveys during the EIS. It was clear from the field conditions that the floods which had occurred since the previous surveys (2009) had significantly impacted all sites via reduction in the availability of suitable microhabitat including at Mt Rose.

On the basis of the findings of the EcoSM survey and earlier BAAM (2012) survey of Mt Rose, further surveys were conducted in March and April 2013 (**Appendix B28-B**). Conditions were again suited to snail sampling, being warm and with occasional rain. Snails were not aestivating. An intensive survey of Mt Rose covering almost every possible area of habitat and taking 96 hours of survey effort, found 3 live adult snails in flood debris near the highest point on Boggomoss 14 (Amec 2013), the original site detailed in the Recovery Plan (Stanisic, 2008). No sub-adults, or juveniles were found at the site. No snails were found on the other two boggomosses on which snails were previously recorded despite searching all available microhabitats. On the basis of survey intensiveness at this site it was considered that the total population at the main site was unlikely to be significantly greater than the number of snails found because essentially the entire potential habitat had been sampled.

The Amec surveys recorded live snails at four of the five downstream sites investigated and three had multiple age classes present indicating repeated successful breeding and recruitment despite the floods. The sites were Isla Delusion, Southend and Nardoo. At Nardoo, 125 live snails were found (including 25 adults), being by far the highest number found from any survey of any site since the species was first recorded. Only 0.2 ha of habitat was searched at Nardoo from a (then) estimated 55 ha of potentially suitable habitat. The search area at neighbouring Southend was 0.244 ha and returned 14 snails (5 adult) within a (then) estimated suitable habitat area of approximately 16.64 ha. Similarly at Isla Delusion 8 snails (4 adult) were found in a 1.27 ha search area from a (then) estimated suitable habitat area of approximately 14.4 ha. While Amec mapped the suitable habitat at each site they relied upon earlier estimates of the area of such habitat. The area within the snail habitat as shown in Amec (2013) and reproduced here as **Figure 28-1** has been re-calculated and is Mt Rose 2.4 ha, Gyranda 13.0 ha, Isla Delusion 142.7 ha, Southend 167.1 ha, Nardoo 91.0 ha and Kia Ora 32.9 ha. Note that the area shown by Amec as Gyranda only constituted the area they searched but did not include the area searched by SKM (2009) in which a live snail was found. The combined two areas have been shown here.

The report concluded that the species is clearly more abundant at several downstream sites than it is at Mt Rose. The population at Mt Rose exists at a single site and the available habitat area is very small. The long term sustainability of the population at Mt Rose was described as "dubious". A number of downstream populations represented robust breeding populations within large habitat areas and they had clearly survived the recent floods in sufficient numbers to re-populate their local area.

The Threatened Species Scientific Committee listing advice for the species refers to an unknown source as suggesting the species had a 50% probability of extinction in the wild within 20 years. The advice also notes that the Mt Rose population is the result of opportunistic flood related colonisation and given its small size and the threats to which it is subject, its long term survival prospects "appear limited". Unfortunately these comments appear to have been substantiated by recent natural events and while individuals still survive at the site, it is unlikely that the site supports a viable population and if it does, long term survival prospects for that population are very limited.

28.1.2.3. Known distribution of the species

The level of knowledge change as a result of the surveys undertaken since the publication of the Recovery Plan (Stanisic 2008) is significant and is summarised below.

- The extent of occurrence at the time of the Recovery Plan was the distance from Mt Rose to Isla Delusion, some 67 km (AMTD). That distance has been extended to Kia Ora, making it approximately 90 km and an increase of over 34%.
- The area of occupancy in the Recovery Plan was estimated as 43.8 ha though this was an over-estimate as it included the full area of one land parcel instead of only the area of suitable habitat within the parcel; the true area of suitable habitat on that lot is 14.9 ha. The area of occupancy at the six main sites (and correcting for the original over-estimate) is now over 449.1 ha which represents a 30 x increase.
- The area and extent of habitat has increased in line with the area of occupancy and the quality of habitat has increased because the newly found sites are less susceptible to some threats than the original sites.
- The number of locations (as individual recording sites) has increased from 2 to 19 and the number of subpopulations from 2 to at least 6.
- The total number of mature individuals recorded (counted as adults) at the time of the Recovery Plan (from 3 sampling events) was 4 while just the latest survey by Amec (2013) recorded 39.

Mt Rose has always been regarded as the most upstream remaining population. The distribution of sites searched since the work of Ingram and Stanisic (1997) is shown in **Figure 28-3**. Despite a significant search effort over a number of years purposefully directed at identifying if any more upstream sites existed, no live individuals have ever been recorded. A single shell was recorded by Ingram and Stanisic from Cockatoo Creek but that site and several patches of potential habitat near it have been re-surveyed several times with no evidence of the species being found.

While the possible colonisation of sites through downstream flood transport of individuals has been suggested, no realistic means to recolonise in an upstream direction has been put forward. As such, as so few snails currently live at Mt Rose and natural recolonisation from other sites is virtually impossible, it is unlikely that the site would ever support a viable population again (Amec 2013). The most upstream site other than Mt Rose is Cabbage Tree Creek (a tributary that joins the Dawson River within Nathan Gorge) which is some 20 km (by river) downstream from Mt Rose while the proposed dam wall is approximately 11 km downstream.

The most downstream live snails have been recorded at the property Kia Ora, approximately 9 km upstream from Theodore and 80 km downstream from the proposed dam site. While some sites further downstream have been investigated, the intensity of survey is very low compared to the upstream area so the result may not reflect the full extent of downstream distribution.

The species has been found at a number of sites between Mt Rose and Kia Ora and several of these have been combined within six habitat areas thought to represent likely sub-populations (Amec 2013, **Appendix B28-A**). At least three of these currently maintain breeding populations (demonstrated by diversity in age classes) following the recent floods. It is also assumed, as it was in the Recovery Plan, that the species may exist at any patch of suitable habitat in between though the suitability of any such patch for long term maintenance of a population is either unknown (has not been inspected) or is thought less than that of the identified sub-populations based on the size and condition of the habitat area. **Figure 28-1** shows the six main habitat areas (Mt Rose, Gyranda, Isla Delusion, Southend, Nardoo and Kia Ora). In between those areas the Dawson River and at times its anabranches contain significant areas of riparian zone which match the regional ecosystems in which the species has been found. Some of these have been searched, though not intensively, so these areas are currently regarded as “potential” habitat. Hence the species currently occupies habitat patches along an approximate 90 km length of the Dawson River between Mt Rose and the lower end of Kia Ora. If the Project proceeds that distance will be reduced by approximately 11 km, most of which is within Nathan Gorge and considered very unlikely to contain suitable habitat.

It is unfortunate that the listing advice stated “the likelihood of Boggomoss Snails occurring elsewhere is low, as most of the suitable habitat in the area has been surveyed” and similarly the Recovery Plan referred to the Isla Delusion site as “the last relatively undisturbed vestige” of suitable habitat. Both comments were clearly incorrect and more recent surveys have repeatedly stated that there is still further potential habitat that has not been surveyed so the existing known sites should not be regarded as the only sites at which the species occurs or potentially occurs.

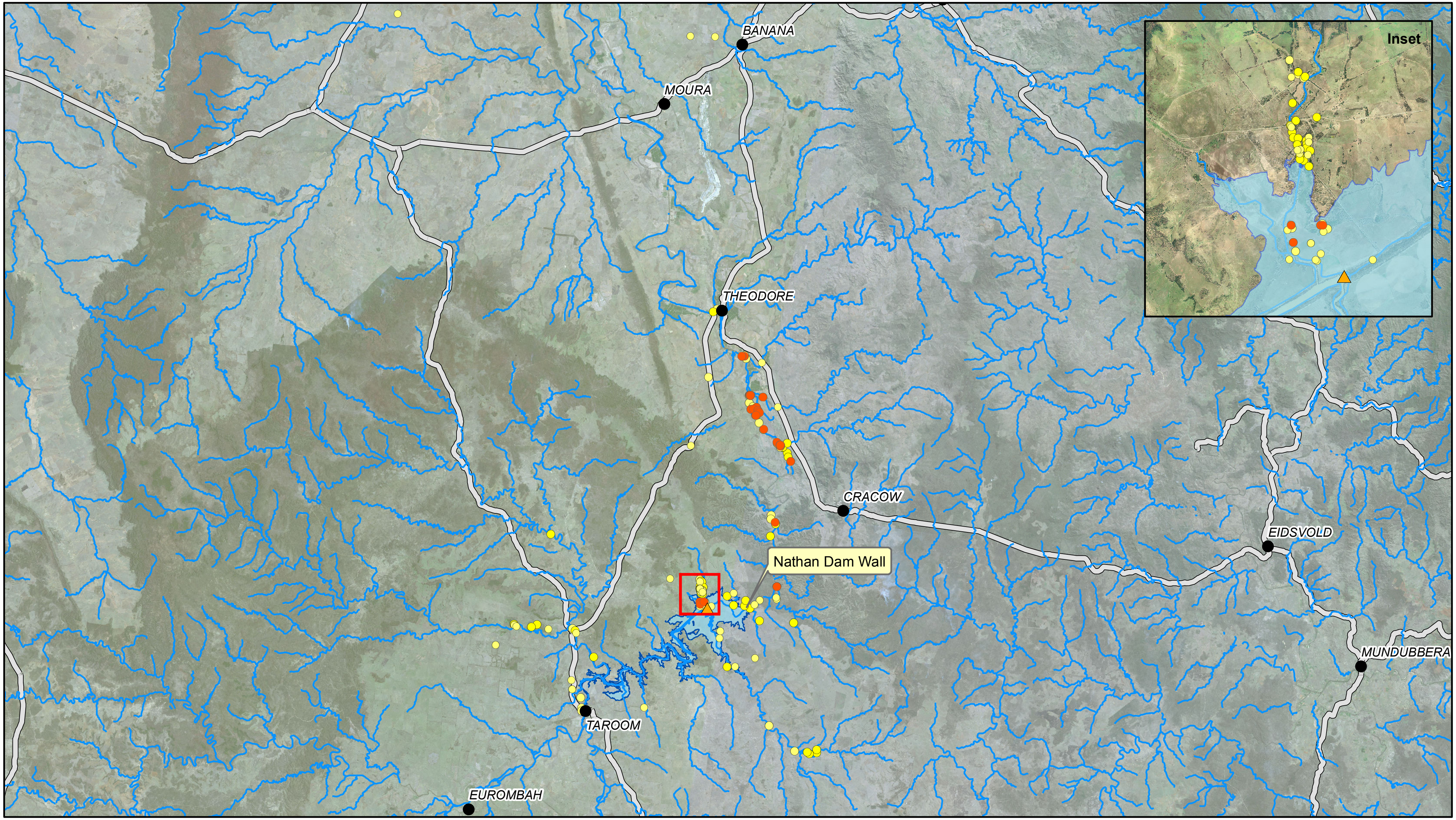
The peer reviewer for the population estimate component of the Project reviewed a draft of this chapter and agreed:

- that the population at Mt Rose is likely to be extremely small;
- the existence of a sustainable population at Mt Rose is unlikely;
- that the historic densities at Mt Rose are not exceptional;
- that the species is clearly more abundant at several downstream sites than it is at Mt Rose;
- that the upstream extent of distribution is well documented (so the most upstream site is Mt Rose);
- that more sites are likely to exist downstream; and

- with 14 of 15 comments made in the draft AEIS.

The one comment with which the reviewer did not agree was deleted so is no longer in this document.

SunWater did not entirely agree with all of the reviewer’s comments but interpreted them as largely supportive of its efforts and most of its conclusions.



LEGEND

- Areas searched where live snails were found
- Areas searched where live snails were not found
- Town
- Weir
- Watercourse
- Main Roads
- Full Supply Level (183.5 m AHD)

Projection: GDA94 Zone 56

Figure 28-3

0 4 8 12 16 20
Kilometres

N

Scale 1:1,000,000 (at A4)

SKM SunWater Making Water Work

ADDITIONAL INFORMATION TO THE NATHAN DAM EIS

Historic Boggomoss Snail Survey Sites

Path: I:\QENV2\Projects\QE06601\QE06601.280 Spatial\ArcGIS\Figures\Final\Additional Information to the Nathan Dam EIS\160415_NathanDam_Ecology_Figure28-3_HistoricBoggomossSnailSurveySites.mxd Produced: 15/04/2016

28.1.2.4. Impacts of the Project on known sites of occupancy

A submitter suggested SunWater should address impacts of the action on each known site of occupancy of the Boggomoss Snail rather than the total number of animals impacted by the Project. Mt Rose is the only site to be directly affected by the Project so it was specifically assessed. Site D11 of SKM (2009) was in Cabbage Tree Creek (a tributary that joins the Dawson River within Nathan Gorge) some 300 m upstream of the confluence with the Dawson River so will be unaffected either directly or indirectly by the construction or operation phases of the Project, so it was not considered any further.

On page 28-81 of the EIS SunWater reviewed the threats to the species as listed in the Recovery Plan. Section 28.5 of the EIS addressed the potential impact of flow regime changes downstream from the dam during the operations phase. Perhaps not clear was that of the recognised threats, flow regime change was determined as the only relevant impact of the action in these downstream environments. This is because:

- no works, therefore no direct impact associated with the Project will occur in these areas;
- no indirect construction phase impact could potentially affect the downstream riparian sites;
- at these sites, the action itself has no effect on the other threats identified in the Recovery Plan; land clearing, fire, grazing, weeds or earthworks;
- flooding of riparian habitat was recognised in BAAM (2009) as a potential threat to snails living in riparian areas (by drowning, dislodging the snails or removing their leaf litter habitat); and
- the listing advice and the Recovery Plan suggested changes to hydrology via interruption of normal river flows had the potential to dry the riparian zone.

As a result, besides commenting on Mt Rose, the EIS placed emphasis on addressing potential impacts resulting from changes to the flow regime at sites downstream of the dam. The species has been found at a number of sites between the proposed dam and Theodore and was thought likely to occupy further sites that had not been assessed by field survey. The main area in question is from the downstream extent of Nathan Gorge (so downstream of the Great Dividing Range) to upstream of Theodore Weir pool and this stretch is relatively hydrologically uniform and dominated by weir pools. As such, flow regime change was assessed using two locations which were known to support the species in relatively good numbers (Isla Delusion Crossing and Southend) and which had available cross sections in order to show the extent of potential flow related change. Due to the uniformity of the reach, the assessments would be suitably applicable throughout the reach.

The decreased flooding regime which results from the dam being in place was evident at both cross section sites and would be expected to be similar throughout the reach. This was interpreted as reducing risk to the snail at all locations. The apparent impact of recent floods on snail populations in the riparian zone is indicative of the significance of this reduction in risk afforded by the dam.

Supplemented supply flows provided by the dam only affected the very low flow regime so would have no physical impact on snail habitat at any site.

The potential for drying of the riparian zone as a result of the reduced flood frequency was viewed as limited because:

- vegetation in the riparian zone does not only rely on floods. Groundwater, rainfall and riverine baseflows were also considered important;
- baseflows during the dry season are and will be maintained at higher than natural levels as a result of releases for downstream users and therefore act to decrease drought related impacts on riparian vegetation; and
- weir pools within the reach maintain water at higher than natural levels and thereby provide the riparian zone with greater water security than would be the case naturally.

Similarly the snail lives on or near the soil surface in moist litter and the moisture in this environment would not be maintained by floods but by rainfall, the shading offered by the tree canopy and by a continuing supply of leaf litter. The points above suggested that the riparian zone would be unlikely to be any more water stressed following dam construction so the health of the riparian zone and hence its litter production would not be impacted.

The EIS concluded that no significant impact was expected on the riparian zone downstream from the dam and therefore no impact on any individual site from which the snail was known or in which it might be found. The major impact, a reduction in flood flows, was interpreted as beneficial to the Boggomoss Snail because it reduced the potential impact of a major threat. As such, no mitigation or offset was required in relation to Boggomoss Snail habitat in these areas.

28.1.2.5. Translocation as a mitigation measure and likelihood of success

DoE commented in their correspondence of 5 June 2012 that “the Department does not consider translocation as a mitigation measure”. This is not a view which had been expressed previously. SunWater originally proposed translocation because it was suggested in the Recovery Plan. Substantial discussions were held with DoE regarding a trial translocation study, designing the process and determining how success would be measured. When SunWater surveys discovered several more populations of the species, DoE communicated that a trial of the translocation process was no longer warranted. Appendix 11E of the EIS described a proposed relocation process prepared by Dr Stanisic, author of the Recovery Plan. Dr Stanisic noted “relocation of the Mt Rose populations of the snail would seem to be the only means of mitigating the impacts of the dam on the snail” and recommended “That the populations of the Boggomoss Snail currently extant on the Mt Rose boggomosses be relocated to suitable habitats outside the dam’s inundation area”.

However since that time, the EPBC Policy Statement “Translocation of listed threatened species – Assessment under Chapter 4 of the EPBC Act” (DoE 2013) was released. The Policy states “Translocation of threatened species is often proposed as mitigation, compensation or offset”. Subheading 2 is “Where translocation is proposed as mitigation” and it does not question whether mitigation is the appropriate term or not but comments on the likelihood of success of the measure. In accordance with the Policy, the translocation proposed in the EIS would be termed “salvage translocation” wherein the snails would be removed from an area adversely affected by the action to an area protected from ongoing impacts.

The Policy is distinctly not in favour of translocation and notes that due to the low likelihood of success, when assessing an action that includes a proposal to translocate individuals, the proposed removal of individuals from the site should be regarded as equivalent to the complete loss of those individuals. In addition, the Policy suggests that the impacts of translocation may be greater than the benefits, particularly with respect to possible impacts on the target (receiving) site. The Policy states that "translocation should not be contemplated unless there is clear evidence that demonstrates a high probability of long-term success". Appendix 11E of the EIS listed a number of "accidental" relocations of snails in Australia that had been successful in terms of the relocated species establishing a population so it is suggested that a managed relocation should have a higher chance of success.

Given this and the very low numbers of individuals at Mt Rose, SunWater proposes that salvage translocation is undertaken with all individuals collected from Mt Rose and transferred to an area of suitable but currently unoccupied habitat within areas that are proposed to be protected as Nature Refuges or other conservation areas. The receiving site would be less at risk from flooding or other threats than the existing site and the aim would be that a viable population is established at the site. With agreement from DoE, the receiving site could be:

- a suitable nearby boggomoss on Mt Rose or Boggomoss Station (the site to be included within SunWater's proposed protected areas for springs); or
- a suitable site of riparian habitat within Spring Creek within SunWater's proposed northern wildlife corridor and adjacent to Precipice National Park.

The site would be monitored to determine the success of the mitigation.

Alternatively should DoE not favour translocation as suggested here, then SunWater offers to support salvage of the individuals at Mt Rose and transport to a research institute such as the Queensland Museum.

Impacts to the habitat at Mt Rose cannot be avoided (because it will be inundated by the water storage) however SunWater believes the mitigated impacts on the population are acceptable. An offset is therefore required for the unavoidable loss of the area of habitat and SunWater has proposed that the offset constitute protection in perpetuity of areas of habitat in which the Boggomoss Snail has now been found and which are outside the area of impact of the Project (that is, at some of the downstream sites which support substantial populations).

28.1.2.6. Outcomes from implementation of Recovery Plan actions

The Recovery Plan for the Boggomoss Snail Adclarkia dawsonensis (Stanisic 2008) recognised a lack of knowledge of the species and included formal actions to improve knowledge in critical areas. The Plan also acknowledged that satisfaction of actions related to improved knowledge would then facilitate better management and provide confidence that actions were appropriate. This accords with standard planning practice in which Plans are not static but evolve as knowledge improves thus fostering continuous improvement and appropriate allocation of resources.

SunWater has sponsored a number of surveys and investigations as part of fulfilling the Terms of Reference for the Nathan Dam and Pipelines EIS which allow actions nominated within the Recovery Plan to be either completed or substantially completed. Further, other approved recovery actions can now be modified and re-focussed due to these changes in knowledge and this accords with the process of implementation of the Recovery Plan.

Each applicable action, performance criteria and justification as stated in the Recovery Plan and the outcome of satisfying it is addressed below. This is followed by an update of other actions which results from satisfaction of the primary actions. The order of presentation of actions differs from the Recovery Plan simply to facilitate a more logical sequence.

Outcomes from Actions undertaken

Action 3.1: Conduct scientific surveys of the Taroom-Theodore area.

Performance criterion: Knowledge of distribution of the snail has increased and results of surveys have been documented in a report.

Justification: Surveys will potentially identify additional boggomoss snail populations and habitat or add confidence that the known populations are the only population.

Outcome: SunWater has funded the following surveys of the Taroom-Theodore area and each produced reports which are available on the SunWater web site:

- BAAM. 2009a. Results of Boggomoss Snail survey. Report for SunWater.
- SKM. 2009. Nathan Dam Project. Survey for the Boggomoss Snail. Report for SunWater.
- JKR Ecological. 2010. Nathan Dam Project. Survey for the boggomoss snail, Report prepared for SKM Pty Ltd.
- Ecological Survey and Management (EcoSM) 2012. Nathan Dam and Pipelines Project. Results of surveys for boggomoss snails, Report prepared for SKM Pty Ltd.
- Amec. 2013. Targeted surveys for the Boggomoss Snail (Adclarkia dawsonensis). Report for SunWater.

The information within the reports formed the basis of much of the discussion in earlier sections of this chapter. SunWater is also aware of the following reports;

- BAAM. 2012. Report on the populational status of the critically endangered Boggomoss Snail at Mt Rose Station and Isla Delusion camping reserve. Report to Wildlife Preservation Society of Queensland.
- Robinson W. A. (2013) Review of Boggomoss snail populations. Technical Report to the Queensland Coordinator-General's Office, November, 2013.

At the time of production of the Recovery Plan the Boggomoss Snail was thought to exist at two sites and as two populations. The SunWater surveys located the species at an additional 17 sites which are interpreted as containing at least 4 additional boggomoss snail populations (Amec 2013). This is a significant increase in knowledge of the species.

As a result, it can be stated with confidence that the original known populations at Mt Rose and Isla Delusion are not the only populations and the habitat at those locations is not the only suitable habitat.

The new reports also estimated the area of suitable habitat at each site and agreed with the Recovery Plan that Mt Rose was a very small patch of suitable habitat (maximum 2.4 ha) while all other sites were larger and have since been estimated at up to 167.1 ha (at Southend).

As the Recovery Plan was written at a time when only two populations and two sites were known, the original actions often referred specifically to just those two sites. As a result of completion of Action 3.1, other actions and management approaches can be modified in order to achieve the best conservation outcomes for the species.

Action 2.3: Conduct field investigations to investigate significance of other threats (e.g. predators); develop a management plan; and implement actions identified in the management plan.

Performance criterion: A report (and management plan, if required) is produced on the significance of other threats.

Justification: It is important to better understand the significance of the other threats to determine whether investment in management of these threats is required.

Outcome: Surveys completed by BAAM (2009) at Mt Rose found that the dead shells showed a high level of damage spread across all size cohorts presumably by mice (Mus musculus) and rats (Rattus fuscipes) which were identified from a trapping exercise conducted concurrently. It is unknown whether the damage occurred pre or post mortality.

The survey reports have often commented on evidence of fire and feral animals, particularly pigs. These can affect any site but the risk of severe damage or local extinction is greater at small sites, such as Mt Rose, Cabbage Tree Creek or Gyranda and the risk is difficult or impossible to fully mitigate. This leads to a preference for protection and investment in management of threats at naturally larger sites as they are more robust and likely to recover from damage should it occur.

Natural flooding was shown to be a significant threat to the species but some habitat areas were shown to be less susceptible than others. JKR (2010), EcoSM (2012) and Amec (2013) specifically included assessment of flood related impacts and showed that Mt Rose and Gyranda were most severely impacted with respect to habitat disturbance while sites such as Isla Delusion or the anabranch channels on Southend, suffered less habitat loss. It was suggested that the sinuous and anabranching nature of the river in the region below Nathan Gorge led to lower energy flows in these systems and less capacity of the floods to strip the leaf litter and other debris.

Mt Rose is clearly and unequivocally the area and sub-population at most risk in relation to the identified threats because of its very small area, very small population, being surrounded by agricultural activity, evidence of significant predation by rodents, known impact of floods and high risk of fire damage. EcoSM (2012) noted "populations of the species on these isolated mound springs are highly vulnerable to one-off stochastic events and subsequently to local extinction". Amec (2013) concluded "The long term sustainability of this population is very questionable" and "the long term probability of extinction of the species at Mt Rose is higher than at other known sites". That conclusion was independently reviewed by a population ecologist who agreed with it (Robinson 2013). The conclusion also mirrors the original Listing Advice for the species which noted a high risk of extinction at Mt Rose due to its very small size.

In deciding the appropriateness of management actions regard must be had to (amongst other things) the most efficient and effective use of the resources that are allocated for the conservation of species and ecological communities (EPBC Act s270(3)(b)). The SunWater reports suggest that the larger downstream sites afford the snail some natural protection from key threats such as flooding, predators or fire while the smaller upstream sites cannot do so and despite likely significant expenditure on management of the threats, success could not be guaranteed. As such the focus of management actions should be on the larger downstream sites.

Action 4.2: Conduct research into the ecology and life cycle of the boggomoss snail.

Performance criterion: Based on the research reports/papers are produced.

Justification: An improved knowledge of ecology of the snail will facilitate better management of the species.

Outcome: The noted surveys and reports included specific examination of aspects of ecology and life history. The improved knowledge includes:

- Examination of the distribution of the species in relation to vegetation types and micro-habitat characteristics. The majority of the known or likely habitat is within RE 11.3.25. At four of the main locations the snail was found in riparian woodlands dominated by Queensland Blue Gum (Eucalyptus tereticornis), Carnarvon Palm (Livistona nitida) and Coolibah (Eucalyptus coolabah). Within the palm forests, the 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 and the shade they afford.

- Deep moist leaf litter is a key determinant of distribution. JKR (2010) noted that the distribution of the snail was very similar to that of the Carnarvon Palm, though the snail was not found in the extensive palm forests along Palm Tree Creek (near Taroom). JKR suggested this may relate to the inability of the sandy substrate in this region to maintain moisture, as opposed to the self-mulching clays of the middle and lower Dawson.

- Targeted investigations have not shown any particular association with either Sandpaper Figs or large logs, as had been earlier suggested. If a relationship with large logs exists, it may relate to a preferred location for aestivation, though this has not been tested.

- All life cycle stages occur in the same habitat (Amec 2013).

This improved knowledge suggests better management of the species can be achieved by focussing on the middle to lower Dawson River in areas of habitat which maintain deep moist litter sourced from the key identified vegetation types and including Carnarvon Palm while not focussing on Sandpaper Figs or logs. Such a focus suggests emphasis on the Isla Delusion to Nardoo region.

Action 1.3: Undertake field surveys to identify and map all essential habitat and habitat critical to the survival of the boggomoss snail.

Performance criterion: A map is produced detailing essential habitat and habitat critical to the survival of the species.

Justification: Mapping is an essential tool for managing spatial data.

Outcome: The reports can be used to identify habitat critical to the survival of the species. Essential habitat is a term used under the Queensland Vegetation Management Act and is not addressed here.

JKR (2010) concluded that "in terms of long term population viability, the largest and most intact habitat systems which support viable sub-populations of the species occur downstream of the Isla-Delusion crossing". Amec (2013) concluded that the most significant habitats for conservation of the species were between Isla Delusion and Theodore.

For the purposes of the recovery plan provisions in the EPBC Act, the EPBC Regulation 7.09 identifies habitat which is critical to survival may take into account seven matters (highlighted in the following discussion). Not all are necessarily relevant to each species or community being considered. The conclusions from the new surveys and the information upon which they were based can be examined in relation to the nominated criteria.

With respect to criteria a) **Whether the habitat is used during periods of stress (e.g. flood, drought, fire)**; snails cannot move to particular habitats in order avoid impacts from flood, drought or fire however some areas of habitat are naturally more or less susceptible to these threats. Survey reports have identified that smaller areas of habitat (such as Mt Rose) are more susceptible to fire and this agrees with the Recovery Plan and broader ecological understanding. Areas upstream or immediately downstream of Nathan Gorge are more susceptible to flood impacts while the more downstream sites appear less so. As the species lives adjacent to the regulated Dawson Valley Water Supply Scheme, it is not highly susceptible to drought. Large areas of habitat near the river best satisfy this criteria and this indicates areas between Isla Delusion and Nardoo.

With respect to criteria b) Whether the habitat is used to meet essential life cycle requirements (e.g. foraging, breeding, nesting, roosting, social behaviour patterns or seed dispersal processes); the nominated essential life cycle requirements relate more to migratory birds or plants whereas the Boggomoss Snail completes all stages of its life cycle in a single habitat. All suitable habitats can meet essential life cycle requirements but some can do so more consistently than others, for example those at less risk from fire, flood or predators or which are within larger areas of essentially natural vegetation. In those terms, the habitat from Isla Delusion to Nardoo best satisfies this criteria.

With respect to criteria c) The extent to which the habitat is used by important populations. The explanatory notes provided in the compliance check list for recovery plans (DoE 2014) states; "In order to identify important populations a plan should identify: how many populations there are; and whether any particular (sub) populations or the whole population is/are necessary for long-term survival and recovery and why, referring to their size and importance". As noted, the survey reports emphasise the repeated breeding at sites from Isla Delusion to Nardoo, the likely size of the populations at these sites (based on catch per unit effort or proportion of habitat searched), and the apparent lower risk from the threat of floods at these sites as reasons to consider them the most viable. This was contrasted with Mt Rose and given its very small physical extent, small population size, likelihood of becoming extinct in the short term and long distance from any other sub-population, would not be considered an important population. Under this criteria, Nardoo, Southend and Isla Delusion are used to the greatest extent by important populations.

With respect to criteria d) Whether the habitat is necessary to maintain genetic diversity and long-term evolutionary development; there is no information available on this issue.

With respect to criteria e) Whether the habitat is necessary for use as corridors to allow the species to move freely between sites used to meet essential life cycle requirements; this criteria relates to situations more like migratory bird stopovers so is not relevant to the species.

With respect to criteria f) Whether the habitat is necessary to ensure the long-term future of the species through reintroduction or re-colonisation. This term can be interpreted two ways; if it relates to a site which is currently not occupied but potentially could be, then it does not relate to any of the known sites. However if it relates to the site being the source of individuals for future reintroductions at other sites, then the sites with the most robust populations with evidence of repeated breeding would best suit the criteria and this again would favour those from Isla Delusion to Nardoo while Mt Rose, Cabbage Tree Creek or Gyranda could not fulfil this role.

With respect to criteria g) Any other way in which habitat may be critical; no relevant criteria specific to any of the known habitats have been identified.

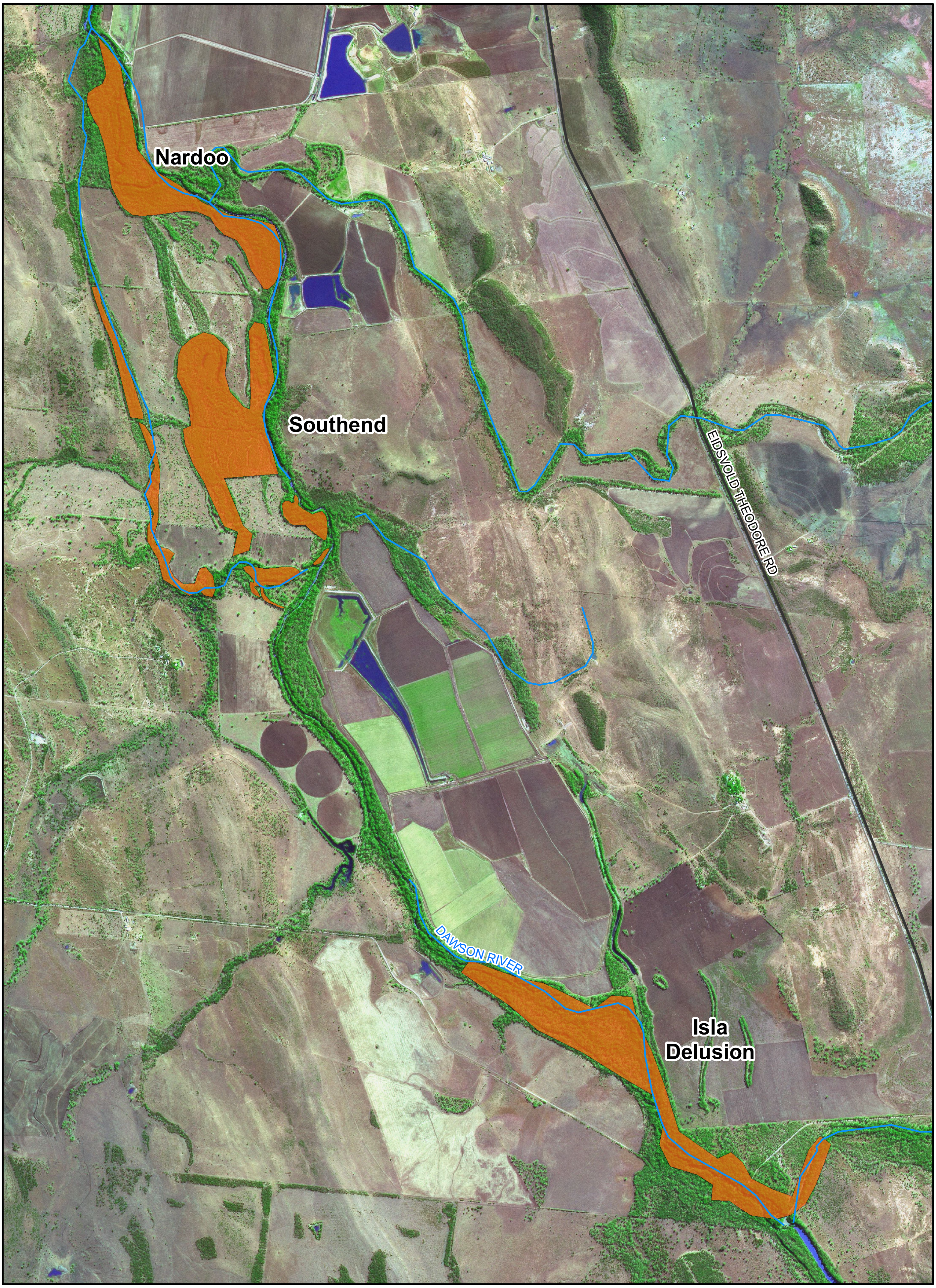
In light of the information presented in the referenced reports, Mt Rose or the other upstream sites would not satisfy any of these criteria. Alternatively, the sites between Isla Delusion and Nardoo which have been shown to contain higher numbers of individuals, repeated breeding and to be within much larger and more secure areas of habitat, would better satisfy the criteria.

Further evidence in the reports can be considering when assessing the applicability of the criteria to the Boggomoss Snail. For the three locations upstream of Isla Delusion and spread over a river distance of 67 km, only low numbers of snails were ever recorded at Cabbage Tree Creek or Gyranda and none were found after the floods of 2011/12 (each site has only been sampled twice). Mt Rose has been sampled multiple times since 1996 and recorded 12, 27, 0, 0, 3; the last three being after the floods and the very last being a full census. The total area of suitable habitat at these three locations has been estimated at about 17.6 ha with Mt Rose on its own representing less than 2.4 ha. This upstream area appears sparsely populated and was strongly impacted by the floods. As detailed above these locations are not considered to represent important populations.

In comparison, the four locations downstream; Isla Delusion, Southend, Nardoo and Kia Ora, are within a river distance of just 27 km of each other, have shown repeated breeding after the floods and the area of suitable habitat at these four locations has most recently been estimated at approximately 433.7 ha.

At Southend the species has not just been found adjacent to the main river but on two anabranches, with others not yet investigated. There is a significant area of likely habitat that remains unsearched in this lower area but much less in the upper area (which includes the inhospitable Nathan Gorge). The downstream block of habitat currently sustains by far the majority of individuals and is considered in the reports to be the core of the species distribution.

Using the above criteria, habitat critical to the survival of the species is located at Nardoo, Southend, and Isla Delusion. The location and configuration of this habitat is presented in (Figure 28-4). Habitat critical to survival is not located at Mt Rose, Cabbage Tree Creek or Gyranda.



LEGEND

- Watercourse
- Main Roads
- Areas within which Habitat Critical to the survival of the species exists

Projection: GDA94 Zone 56

Figure 28-4

0 250 500 1,000 1,500

Meters

Scale 1:50,000 (at A4)

N

SKM

SunWater

Making Water Work

ADDITIONAL INFORMATION TO THE NATHAN DAM EIS

Areas Within Which Habitat Critical to the Survival of the Boggomoss Snail Exists

Path: \\Jacobs.com\BNEProjects\QENV2\Projects\QE06601\QE06601.280 Spatial\ArcGIS\Figures\Final\Additional Information to the Nathan Dam EIS\160422_Figure28_4_AreasWithinWhichHabitatCriticalToTheSurvivalOf TheSpeciesExists.mxd Produced: 22/04/2016

Resultant modification of other Actions

Satisfaction of the actions noted above has led to modification or better focussing of other actions within the Recovery Plan which are not yet complete, and this re-focussing is intended by the planning process. In the modifications below, the intended conservation outcome or justification as included within the Recovery Plan actions remains the focus of the action, with the main modification being related to which site or sites should be included within the action. The intent is to use new knowledge to better inform management actions within the framework of the existing Recovery Plan. The EIS suggested that the Recovery Plan should be renewed as a result of the new information gained through the EIS process. The amendment process has commenced and SunWater anticipates the information included here will be taken into account.

Many actions currently refer to undertaking management actions at only the original two locations or populations and this is no longer relevant as a result of completion of other actions within the Recovery Plan. For example the actions related to fire, weed or grazing management should relate to each now known population site.

The action as stated in the Recovery Plan is presented first followed by the modification.

Action 1.1: Undertake field surveys to assess weed problems in the two known habitats of the boggomoss snail and develop and implement control programmes, if necessary.

Performance criterion: A weed assessment report is written and, if required, a weed management plan is written and implementation is reported on.

Justification: Weed infestation has the potential to alter both the lower shrub layer and consequent litter as well as contributing to an increased fuel load.

Modification:

Action 1.1: Assess weed problems in areas of public land at Isla Delusion and in areas protected as a result of Action 2.2. Develop and implement control programmes, if necessary.

Performance criterion and justification remain the same.

Action 1.2: Develop and implement fire risk management plans for the two known habitats of the boggomoss snail.

Performance criterion: There is an appropriate fire regime that maximises the survival of the snails. Fire management plans for the two sites are written and implementation is reported in annual and final recovery plan reports.

Justification: Fire is a major threat to the viability of land snail populations and the small size of the habitats makes them particularly prone to destruction by fire. Fire affects both the snail directly and indirectly through the destruction of microhabitat.

Modification:

Action 1.2: Develop and implement fire risk management plans for the areas of public land at Isla Delusion and in areas protected as a result of Action 2.2.

Performance criterion and justification remain the same.

Action 2.2: Enter into negotiations with owners of the Mt Rose Station to protect the population of snails through a conservation covenant such as a Nature Refuge agreement or another voluntary conservation agreement.

Performance criterion: A voluntary conservation agreement is signed.

Justification: To maximise the protection of boggomoss snails on private land.

Note; while the Recovery Plan included a technical error here because Mt Rose is owned by the State of Queensland so is not private land, based on the new information the protection of boggomoss snails on private land would be maximised by establishing a conservation agreement with the owners of Nardoo or Southend. The two main lots at Isla Delusion are public land but adjoining private property on Lagoona would also be suitable for inclusion in this process. As these properties and areas of habitat are much larger than originally understood in the Recovery Plan, it may not be possible for all of the area to be included in an agreement. As such, multiple agreements covering smaller areas of land is a possible outcome which should be recognised. Hence the action is modified as below:

Modification:

Action 2.2: Enter into negotiations with owners of Nardoo, Southend and Lagoona to protect the population of snails within areas of habitat critical to the survival of the species through conservation covenants such as Nature Refuge agreements or other voluntary conservation agreements.

Performance criterion: At least two voluntary conservation agreements are signed including a total area of at least 10 ha. (It is noted that there is no particular justification for the nominated number of agreements or land area but performance criteria require measurable outcomes so figures are suggested).

Justification: To maximise the protection of boggomoss snails on private land.

The other actions within the plan do not require re-focussing or cannot be modified as a result of the outcomes related to other actions.

28.1.2.7. Assessment against the Significant Impact Criteria

Based on all the data currently available, SunWater has revised the assessment against the EPBC Act significant impact criteria **(Table 28-1**). The impacts of the Project on the species are limited to flooding of the Mt Rose site. There are no other negative direct or indirect impacts in the construction or operations phases.

Table 28-1 EPBC Act Impact Assessment on the Boggomoss Snail

Criteria	Significance of Impacts	Mitigation and Offsets
Lead to a long-term decrease in the size of a population of a species?	The Project will result in the flooding of one site at Mt Rose Station which has historically been thought to contain a "population". That is no longer the case and this site is not considered to support a viable long term population. With or without the Project it is considered that a population will not survive at this site in the long-term. Impact by the Project will not alter the long term outcome.	Remaining snails will be translocated to an area of currently unoccupied suitable habitat with the aim of establishing a viable population. Areas of known habitat downstream will be included in the Project offset strategy and actions in accordance with the Recovery Plan will be taken in these areas to reduce threats to the species.
Reduce the area of occupancy of the species?	When listed, the area of occupancy was noted as 43.8 ha. The total area of potential habitat for the species has not been estimated but the area within the six core sites of known habitat is now estimated as 449.1 ha. The species is very likely to also exist in sections of suitable habitat between known sites. The Project will result in the flooding of the smallest of the known sites which has a potential suitable habitat area of 2.4 ha or approximately 0.5% of known suitable habitat in the region. Flooding of the Mt Rose site will reduce the overall range of the species as it is regarded as the most upstream site.	Translocate individuals from Mt Rose to a nearby area such that there is minimal change in the area of occupancy.
Fragment an existing population into two or more populations?	The Project will not cause fragmentation of any of the recognised sub-populations beyond that which currently exists.	
Adversely affect habitat critical to the survival of a species?	Habitat critical to the survival of the species was identified in Section 28.1.2.6 as at: ▪ Isla Delusion ▪ Southend, and ▪ Nardoo. These habitats will not be affected by the Project.	
Disrupt the breeding cycle of a population?	The last three surveys at Mt Rose have shown no evidence of breeding. Evidence of significant and repeated breeding has been shown at several downstream sites with multiple age classes represented and no change is expected at these sites.	Remaining snails at Mt Rose will be translocated to an area of currently unoccupied suitable habitat with the aim of establishing a viable breeding population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?	The habitat which will be lost at Mt. Rose represents approximately 0.5% of the currently known suitable habitat and a smaller proportion again of the likely suitable habitat. It is not considered that this loss would lead the species to decline as other areas of more substantial habitat and which support breeding populations have been shown capable of surviving significant flood events. The populations at these sites function apparently independently from Mt Rose.	The Project offset strategy will protect areas of habitat critical to the survival of the species.

Criteria	Significance of Impacts	Mitigation and Offsets
Result in invasive species that are harmful to a critically endangered becoming established in the critically endangered species' habitat?	The Project will not introduce or alter the populations of feral animals at the known sites.	
Introduce disease that may cause the species to decline?	The Project will not introduce any diseases.	
Interfere with the recovery of the species?	The Project will inundate one site which is considered not to support a viable long term population. Given the information generated by SunWater (discussed above), this is not considered to interfere with the recovery of the species. The overall objective of the Recovery Plan is to promote the recovery of the boggomoss snail in the wild. The action will not conflict with this objective and it is considered that implementation of the Project mitigation and offset strategies will substantially contribute towards obtaining the objective and significantly enhance the recovery of the species. The Plan recognised that "There is potential for a dam or a weir built on the Dawson River that could eliminate the Mt Rose boggomoss site (Fensham, 1998). However, it should be possible to relocate the snails from the boggomoss site if a structure was built". SunWater has committed to this mitigation strategy. The Plan states "Another possible impact of an impoundment on the boggomoss snail would be the effect of the interruption to normal flows that would result from the impoundment". This has been assessed through the EIS process and determined not to be a possible impact. The specific objectives of the Plan are addressed below. Objective 1. Protect habitat – SunWater has sponsored field surveys and produced maps that allowed the identification of habitat critical to survival and has committed to protect areas of such habitat as part of the Project offset strategy. SunWater has also committed to produce and implement the nominated weed, fire and grazing management plans at those sites. Objective 2. Protect populations – It is noted that Action 2.1 (listing the species under the NC Act) was completed in August 2015. Action 2.2 SunWater will maximise the protection of boggomoss snails on private land by focussing offset efforts on areas of habitat critical to survival. Objective 3. Identify additional living populations – SunWater has sponsored several surveys which achieved this outcome and has committed to undertake actions to protect at least some of these populations. Objective 4. Increase understanding of the distribution and ecology of the species – the surveys sponsored by SunWater have significantly expanded the known distribution of the species while also confirming the limits to the species distribution. The surveys examined micro and macro habitat preferences and the ability of the species to survive floods. SunWater has committed to ongoing monitoring of boggomoss snail sites included within the offset	Translocation mitigation strategy. The Project offset strategy.

Criteria	Significance of Impacts	Mitigation and Offsets
	strategy. Objective 5. Increase public awareness of the species – the EIS process and its associated consultation program has included significant information on the species and has drawn comment from agencies and the public. It is concluded that the Project will not interfere with the recovery of the species and does not conflict with the objectives of the Recovery Plan, taking into account the improved knowledge which logically alters the specificity of some of the plans actions.	

Based on the above SunWater concludes that approval of the Project would not be inconsistent with the Recovery Plan.

Summary and Recommendation

Based on the evidence, SunWater believes the results presented in the EIS and this additional information constitute the best scientific information available on the species and if the mitigation measures are implemented then no significant impact on the species will result. Further, if the mitigation and offsets committed to here are implemented, the survival of the species in the wild will be far more secure than it is at present.

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A consolidated reference list related to the species is provided below. This is drawn from the various studies undertaken for the EIS. SunWater is not aware of any other studies or reports that offer additional information related to the species.

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28.1.3. Fitzroy River turtle

DoE requested further information on the technology of energy dissipation devices to mitigate impacts on the species. The aim with respect to many of the dam design related mitigation measures listed on page 28-120 of the EIS is to firstly keep turtles away from areas where they may be harmed. However during spillway overtopping events, turtles may be transferred over the spillway in a relatively high energy flow. The energy dissipation approach included within the preliminary design is a shallow flip bucket and plunge pool and Section 2.3.1.2 of the EIS noted "This will dissipate flow energy in such a way that minimises stress to fish passing over the spillway whilst achieving minimal erosion downstream of the dam wall". The statement is equally applicable to turtles or other fauna. This is a change from traditional designs which have been observed to cause injury or death to fish and turtles. For example many spillways have employed steps to dissipate energy as the water cascades downs the steps but unfortunately the entrained fauna also cascades. Another common approach is to place vertical concrete stanchions at the base of the spillway to break up the flow, but entrained fauna could be injured by colliding with the stanchions.

The proposed spillway design has removed all such protruding concrete energy dissipation structures (steps or stanchions), such that the spillway apron is smooth. Fauna carried over the apron will be delivered to a plunge pool containing water. There are no hard barriers that may block this passage. Fauna will travel at high velocity down the spillway but will be slowed by the flip bucket (which will operate like the bottom end of a child's slippery slide) prior to entering the plunge pool. From this point the fauna will experience flow velocity and turbulence as they would in natural flood events. Dr Col Limpus of (then) DERM had advised such a "soft landing" was preferred.

One submission recommended that it needed to be established that the proposed turtleway would provide safe passage under all circumstances. This is an intention of the design process, which will involve expert advice and testing of scale models. The EIS clearly acknowledged the uncertainty related to success of any particular design and this is unavoidable because to be able to show with certainty that the design will work on a particular dam, you need to build the dam. As such, SunWater committed not only to the design process noted, but to modify the structure if monitoring showed it was not performing to a satisfactory standard. During such times of unsatisfactory performance and if relevant agencies determined that it was necessary and of net benefit, SunWater also committed to undertake catch and carry procedures to provide effective short term transfer and genetic mixing. This would be undertaken for any turtle species thought to benefit from the procedure.

Monitoring commitments which relate to Fitzroy River Turtle (and other turtle species) made in the construction phase EMP (AEIS Appendix 29 Section 9.13) include:

- Fishway and turtleway for the dam wall designed through collaboration with Fisheries Qld, DEHP and Fitzroy Basin Association NRM Group. Recommendations made within the EIS regarding design elements will be considered.
- Larger native aquatic fauna (fish, turtles, platypus) inhabiting areas likely to be affected by direct physical disturbance during construction will be translocated to alternative areas of suitable habitat. A translocation strategy will be developed.
- Specialist advice will be sought for translocation strategies involving turtles and platypus. All conservation significant turtles will be pit tagged.
- Specific program to monitor translocation procedures.
- Survey to identify turtle nesting areas within and near the water storage area prior to construction.

During operations the relevant monitoring and corrective actions include (Section 10.10 of Appendix B29):

- Annual population surveys of EVNT turtle species will be undertaken during the respective nesting seasons in areas upstream of the water storage area which supports suitable habitat, within the water storage and downstream as far as Theodore Weir to assess the population and the likelihood of nesting (using non-invasive ultrasound techniques). All individuals captured will be pit tagged. Results will be assessed with respect to the monitored flow regime, dam water levels, fishway and turtleway evaluations and changes over time.
- If nesting is observed within the dam catchment, the nests will be protected from predators using mesh cages (as used in the Fitzroy Barrage and Mary River) and the site will be inspected for evidence of hatching at the appropriate time.
- Use of the fishway and turtleway will be monitored and reported.

- Offtakes, outlet structures and the spillway will be inspected for evidence of injury or death caused to turtles and any such observations will be reported to DEHP and Queensland Fisheries. If evidence suggests that design of the screens, stilling basin or outlet structures can be improved to avoid or minimise such instances, feasible and practical modifications will be undertaken as a corrective action.
- Maintenance of fishway and turtleway as required (determined via monitoring).

One submitter suggested that further surveys were required in order to make a firmer conclusion regarding the presence of Fitzroy River Turtle in the project area. SunWater suggests that the existing surveys have been adequate and a precautionary approach to management has been taken, that is, mitigation measures have been included in the Project as if the species is present despite the repeated surveys not finding the species. However it is appropriate when assessing the initial potential for impact on the species and the residual impact after mitigation measures are applied, to appreciate that the species has never actually been captured in the area and the nearest other observation of a live individual is well below Nathan Gorge (at “Cracow beach” near the Orange Creek Weir; Duncan Limpus *pers.comm*). SunWater has continued to undertake aquatic ecology surveys every six months (though not specifically targeting turtles), and water quality surveys each 3 months, since 2012 using the same company who undertook the specific turtle surveys and no Fitzroy River turtles have been captured coincidentally or observed. Similarly SunWater is aware that aquatic ecology monitoring undertaken by Santos in relation to their CSG operations upstream of the proposed dam area over several years has recorded turtles but not Fitzroy River Turtles. The only indication that the species may be present in the project area remains a comment from Dr Col Limpus that he has seen a photograph of a deceased specimen apparently killed on the trash rack at Glebe Weir. The only reports related to turtle deaths on the trash racks (in Limpus et al 2011) recorded 132 individuals across 5 species of turtle, but no Fitzroy River Turtle. Similarly Limpus et al (2011) report the known range of the species as upstream “at least to Theodore”. Theodore is 98 river kilometres below Glebe Weir. While no Fitzroy River turtles have been recorded near the Nathan Dam project, they were recorded near the proposed Connors River Dam site. Limpus et al (2011a), assisting SunWater with a project at Tartrus Weir on the Mackenzie River, recorded the species in relatively high numbers and also recorded the largest ever number of nests of the species. This suggests that if the species is present to any extent, it is usually recorded by field surveys, so supports the contention that if it is present in the area of the proposed Nathan Dam, it is in low numbers and would therefore not constitute an important population.

EHP requested further consideration of the impacts of climate change and associated flow regime change on Fitzroy River turtle, particularly with respect to nesting success and male to female sex ratios. Firstly, temperature dependant sex determination is only known in one species of Australian freshwater turtle (the Pig-nosed turtle) while it has been shown not to be the case in several chelid species (several authors in Limpus et al., 2011). Incubation temperature can however affect hatchling morphology and swimming speed (Eiby and Booth 2011).

Section 14.2.2 of the EIS addressed possible future climate change impacts on the flow regime with the dam in place while sections 28.5.1.3 and 28.5.4.4 specifically addressed aspects of the flow regime which were relevant to Fitzroy River turtle. As the dam reduces the potential impacts of floods on nests while also maintaining low flows that sustain riffles and water quality at greater than natural levels, these changes were interpreted as potentially beneficial to the species. Climate change is most likely to lead to a drying of the catchment so the ability of the dam to maintain these low flows (Section 14.2.2.6 and 14.2.2.7 of the EIS) at critical times is again of benefit to the species. For example the dam would only fall below Minimum Operating Volume for 0.5% of the time in the median climate change scenario. Water storages and regulated water supply schemes are effectively buffers against the impacts of climate change on low flows.

28.1.4. Community of native species dependant on the natural discharge of groundwater from the Great Artesian Basin

DoE and others questioned SunWater's view that the springs within the impact area were not part of the listed community. As noted in the EIS, SunWater was concerned that the definition of the community was confusing, ambiguous and at times conflicting within the various relevant documents (primarily the listing document, the SPRAT profile and the National Recovery Plan). One area of confusion was with regard to the definition of the springs as either discharge or recharge. A published scientific paper on this issue (Fensham and Fairfax 2003) is commonly cited in the various documents and it unequivocally states springs of the Springsure group are all classified as recharge springs hence those in the impact area would not be considered part of the listed community. SunWater has since identified a supporting document to the GAB Water Resource Plan (2006); Fensham and Fairfax (2005) which provides an explanation. That document notes: "The definition employed here for recharge springs and discharge springs is different from that used by Fensham and Fairfax (2003) and Fensham and Price (2004) to define 'recharge springs' and 'discharge springs'. However, the definition employed here for discharge springs is compatible to that used to define the target of the EPBC Act listing of 'The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin' as defined by the draft Recovery Plan for that community". Unfortunately while dated 2010 the Recovery Plan does not reference this report, nor do any of the other key documents noted above, only the earlier report which uses a critically different definition.

The Recovery Plan also refers to "an inventory of GAB discharge spring wetland locations" as a background document and that document (the Queensland Springs Database maintained by Dr Fensham and associates at the Queensland Herbarium) records some springs in the impact area as discharge springs and therefore part of the listed community while others are recorded as recharge springs and therefore not part of the listed community. The version of that inventory used for the EIS (2010) was updated (Pennay *et al* 2012 and again in November 2015) and several springs bordering the Project which were regarded as recharge springs so not classified as part of the threatened community in the 2010 version, are now regarded as discharge springs so are part of the community (springs numbered 26 and 28 were in Dawson 7 but are now in Dawson 8, while springs 40, 41, 52 and 67 were in Dawson 4 but are now in Prices).

It should be noted that the ambiguity regarding the classification of springs as discharge or recharge was not the only area of concern raised by SunWater in the EIS with respect to the inclusion of these springs within the EPBC listed community. Irrespective of any more information that may become available, unless the core documents are corrected or superseded then the conflicts will remain.

The EIS was criticised for using Figure 18 of the GAB Resources Study on the basis that the figure was at an inappropriate scale for impact assessment. The figure was not used for impact assessment purposes but because it is the only figure referenced by the listing document as a means of describing the distribution of the community. SunWater notes that the Recovery Plan also uses only one map (referred to as Figure 1), as does the metadata section of the Queensland Springs Database and they are very similar to each other and to Figure 18 of the GAB Resources Study so are at the same scale. For site specific information SunWater relied upon Fensham and Fairfax (2003), the Queensland Springs database or EIS surveys which included data collected from springs in the Project area.

DoE commented that SunWater had referenced the Recovery Plan as excluding springs sourced from the Hutton and Precipice Sandstone. This is not correct. Page 28-45 of the EIS states (underline added): *The Recovery Plan and the SPRAT profile also clearly state that recharge springs are not part of the listed ecological community. The profile also excludes springs arising from the Hutton or Precipice sandstone and the project only impacts springs that arise from these geological features*. The reference is therefore to the SPRAT profile only and the specific comment is found on page 23 of the Profile under the heading "Similar Ecological Communities". As a "similar ecological community" they are clearly not the same ecological community. That section again references Fensham and Fairfax (2003) as a means to differentiate recharge and discharge springs and as noted above, SunWater relied upon that reference.

DoE commented that SunWater disputes the Recovery Plan inclusion of the Boggomoss complex within those with "exceptional values" on the basis that the Boggomoss Snail is not present. This is also not correct. SunWater does not dispute that the Boggomoss Snail is present but the definition of springs with exceptional values (classified as category 1a springs) only includes springs with spring endemic species present and the Boggomoss Snail is not endemic to springs. This error has been corrected in later relevant documents (Queensland springs database, Pennay *et al*., 2012) such that the highest ranking springs impacted by the Project are category 1b, hence do not qualify as having exceptional values. However the Recovery Plan still contains the error.

For clarity, the Boggomoss Snail is and has always been known as a terrestrial species so is not and should never have been regarded as a member of the "Community of Native Species dependent upon natural discharge of groundwater from the Great Artesian Basin". As noted in the EIS the species is not "associated" with springs so its name is a misnomer and its other common name would be more appropriate, viz, Dawson River Snail. It exists at the spring site on Mt Rose because of the terrestrial vegetation surrounding the spring and the important features of that vegetation are the same as that at riverine sites. That vegetation is also not dependent on the spring and is not part of the listed community. The snail does not exist at springs where suitable vegetation is not present and many springs have been searched without finding it. The three springs where it has been found are in very close proximity to each other and the Dawson River. They are commonly affected by riverine flooding. Snails were only found at two of these sites on one occasion so may have been deposited there by floods but did not survive. The Threatened Species Scientific Committee listing advice for the species notes that the Mt Rose population is the result of opportunistic flood related colonisation so it has no particular link to the presence of the spring.

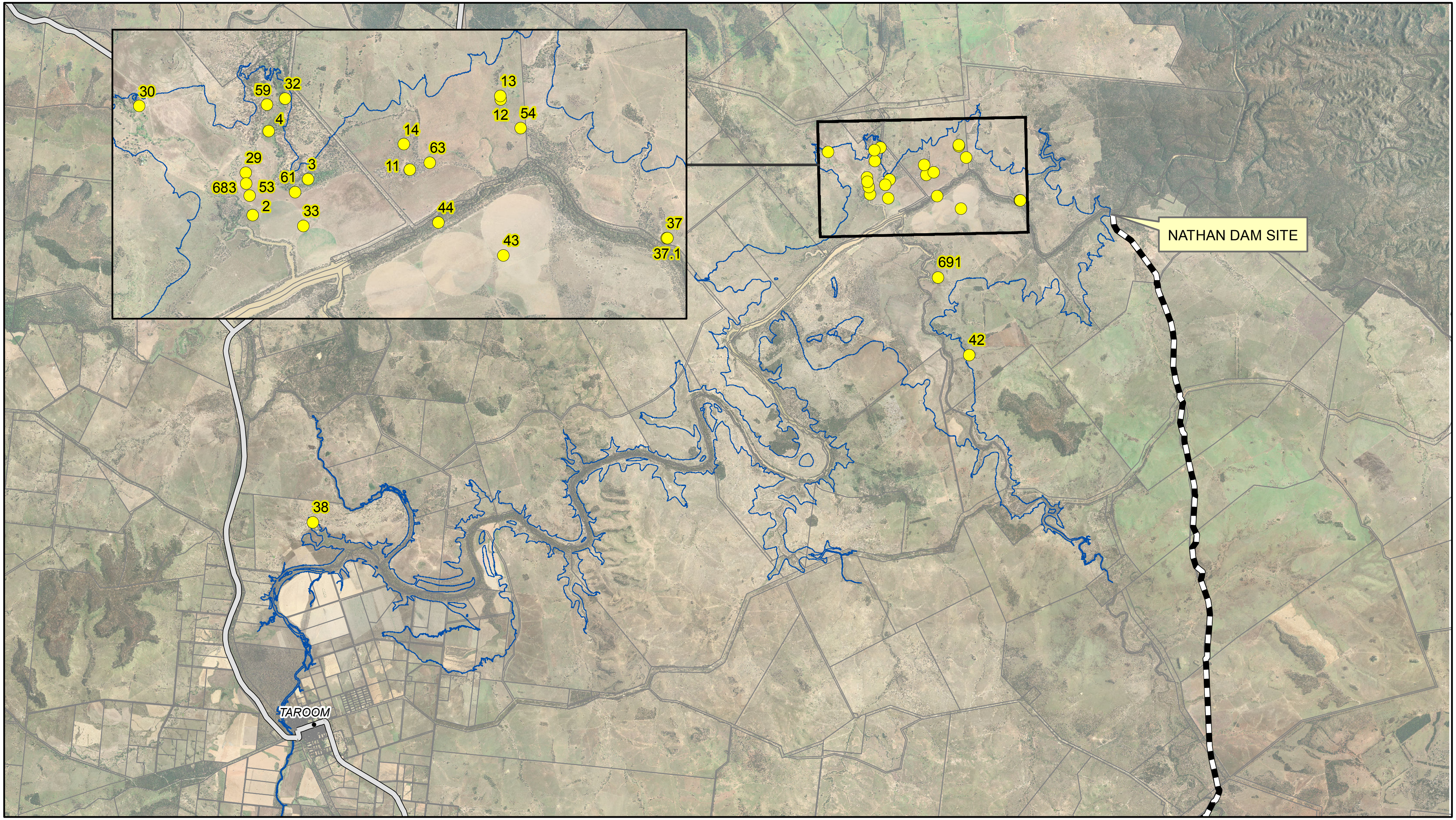
DoE expressed concern over the proposed mitigation measure for springs affected by dewatering. EPBC listed springs are not affected by dewatering. Table 15-9 of the EIS identified all the affected springs and noted they were from the Dawson River 3 and Dawson River 4 complexes. The version of the Queensland Springs database used for the EIS and updated versions specifically identify these complexes as recharge springs and not part of the EPBC listed community. As such, dewatering is not a relevant impact on this MNES. The further groundwater studies reported as Appendix B15 confirm that result.

Table 28-19 of the EIS has been updated (**Table 28-2** below) to reflect the latest information from Pennay *et al*., (2012), the Queensland Springs Database provided by the Herbarium in November 2015 and more detailed topographic information acquired by SunWater. Increased groundwater pressure variously affects most (26) springs outside FSL (except Cockatoo Creek complex). **Figure 28-5** shows the distribution of EPBC listed springs affected by inundation while **Figure 28-6** shows springs not inundated but in the vicinity of the Project.

Table 28-2 GAB springs impacted, near the Project or in the Springsure group

Location	Spring complex and site numbers	Total
Within FSL		
EPBC listed	Dawson River 6: 4, 30, 32, 42, 43, 59	23
	Dawson River 8: 38	
	Boggomoss 5: 2, 3, 11, 12, 13, 14, 29, 33, 37, 44, 53, 54, 61, 63, 683, 691	
	Dawson River 4: 690	
Non-EPBC		1
Outside FSL		
EPBC listed	Dawson River 6: 1, 5, 6, 22, 23, 24, 25, 27, 31, 60, 681	36
	Dawson River 8: 26, 28	
	Boggomoss 5: 7, 8, 9, 10, 15, 55, 56, 57, 58, 62, 68	
	Cockatoo Creek: 64, 65, 66, 319, 320, 321, 684, 685	
	Prices: 40, 41, 52, 67	
Non-EPBC	Dawson River 3: 16, 17, 18, 19, 20, 21, 34, 35, 36, 69	
	Dawson River 4: 39, 45, 46, 47, 48, 49, 50, 51	19
	Dawson River 6: x346	
Other Springsure		
EPBC	Scotts Creek: 189, 190, 191, 192	13
	Lucky Last: 287, 340, 686, 687, 689	
	Crystal Ball: 317, 318	
	Yebna2: 534	
	Elgin2: 540	
Non-EPBC		183

Note: separate spring vents are not counted. For example spring 321 in the Cockatoo Creek complex has 8 identified vents.



LEGEND

- Town
- DERM EPBC GAB Spring Sites (2012)
- State Controlled Roads
- Pipeline Route
- Cadastre
- Full Supply Level (183.5m AHD)

Projection: GDA94 Zone 56

Figure 28-5

0 1 2 4
Kilometres

N

Scale 1:200,000 (at A4)

SKM SunWater Making Water Work

ADDITIONAL INFORMATION TO THE NATHAN DAM EIS

Impact on Spring Sites Within the FSL

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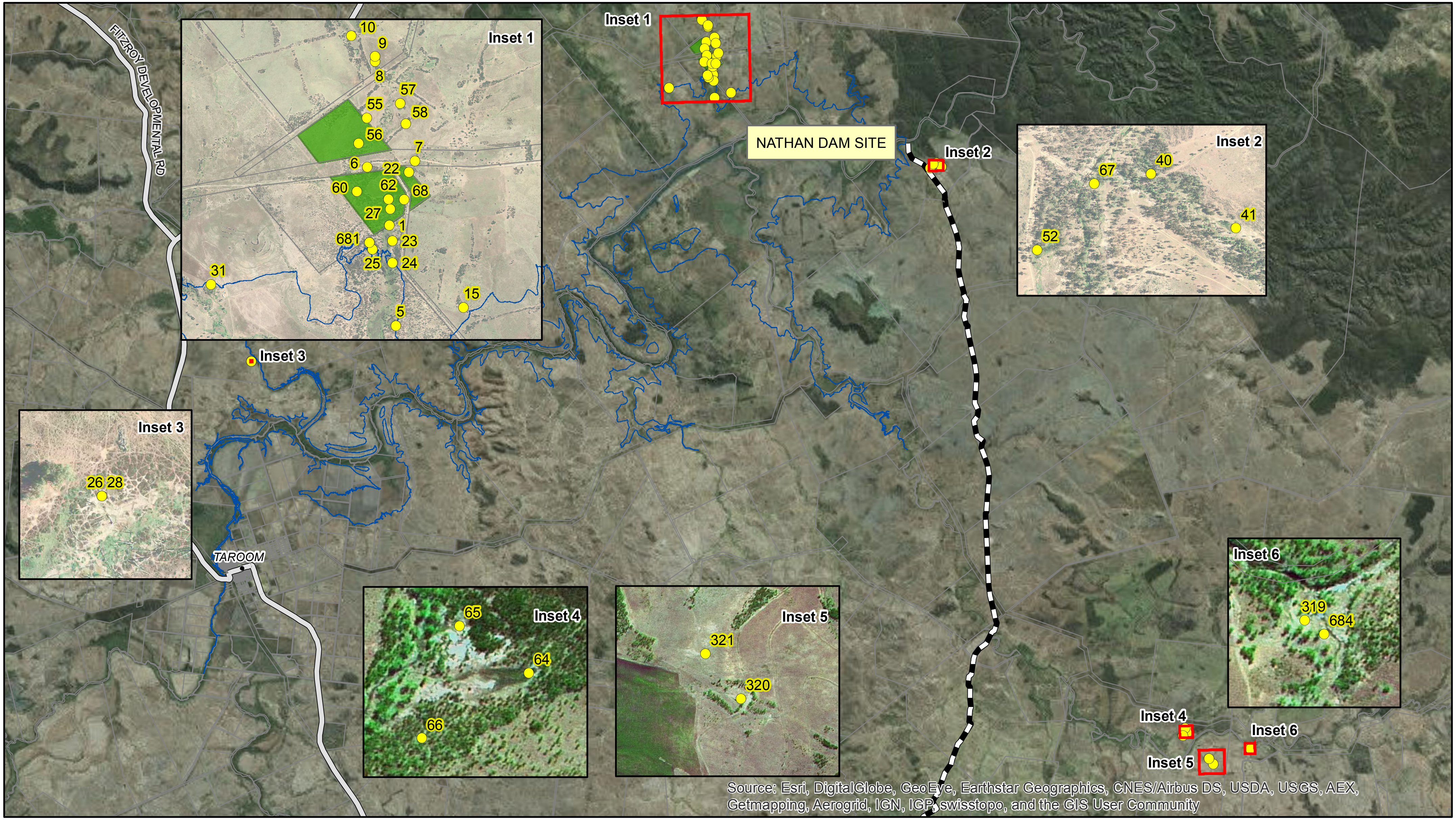

LEGEND

- Town
- DERM EPBC GAB Spring Sites (2012)
- State Controlled Roads
- Pipeline Route
- Cadastre
- Full Supply Level (183.5m AHD)
- Boggomoss Nature Refuge

Projection: GDA94 Zone 56

Figure 28-6

0 1 2 4
Kilometres

N

Scale 1:240,000 (at A4)

SKM

SunWater Making Water Work

ADDITIONAL INFORMATION TO THE NATHAN DAM EIS

Nearby Springs Not Inundated at FSL

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28.1.4.1. Appropriateness of groundwater conceptual and numeric models

Review comments received from DNRM and DoE relating to groundwater focused on the validity of the conclusions drawn on the likely impact of the dam inundation to the groundwater system and associated springs. In essence, the extent and utility of the data and information used to inform the conceptual and numerical models was challenged. Specifically, the following underlying points were raised:

1) the appropriate use of existing data from existing groundwater bores;
2) a need for drilling and construction of new bores to supplement and confirm existing data;
3) appropriate interpretation of new data based on the conceptual understanding of the groundwater system; and
4) understanding the accuracy of the numerical modelling outputs given the limitations of the input data and modelling approach.

To address the above concerns and provide further confidence in the groundwater impact assessment, SunWater commissioned SKM to undertake additional desktop and field based hydrogeological assessments. An independent peer reviewer appointed by Office of the Coordinator-General interacted with SKM throughout the process. These assessments were undertaken over the period from July 2012 to December 2013. The full report is included as Appendix B15 of the AEIS and relevant data from it was also used to address other groundwater issues in Chapter 15. The following is a direct extract from the Summary of the report in Appendix B15.

"The key results of the desktop assessment are:

1) The majority of previous groundwater data relevant to the Project area is focussed on characterising groundwater springs. The majority of data relates to physical and ecological surface characteristics of springs, while in most cases water age and a large range of hydrogeological data is absent.
2) All available data from existing groundwater bores was accessed and reviewed for use in the EIS. A survey of existing bores was not considered necessary but SunWater has committed to undertake such a survey prior to commencement of construction.
3) All new data available for individual spring vents post-EIS was reviewed. There is now more hydrogeological attribute data available. This is mainly surface based information, with subsurface data consisting solely of water sample analyses. Based on this review, the need for further drilling was confirmed and a field program developed to fill specific identified data gaps.
4) A review of conceptualisations of the local Project area groundwater system following the EIS was completed. All studies undertaken since the EIS confirm the results of the EIS conceptual model of spring source aquifer and that the majority of springs in the region are predominantly controlled by faults and aquitard thinning.

   None of the new data collected for springs post-EIS has contradicted the conceptual model developed as part of the EIS.
5) The Nathan EIS impact assessment was generally consistent with the form and level of assessment completed as part of QWC's Underground Water Impact Report, with the exception of the inclusion of a survey of the hydrogeological characteristics of impacted springs. The field program was designed to include such survey.

A field program was undertaken following the desktop assessment to fill the data gaps identified. Key results of the field program are:

1) Temporal data for two existing bores near the proposed dam wall was identified and reviewed. Based on review of the DNRM GWDB, no more groundwater bore data has become available since the EIS (other than that generated by this study).
2) The field program was designed such that co-location of monitoring bores and monitored springs allowed direct comparisons of data gathered from the bores and the adjacent springs. Five new bores have been installed and two existing bores have been refurbished as part of this investigation. Stratigraphic, water level and pressure and water quality data have been gathered from these bores.
3) Water quality analyses suggest that the Precipice Sandstone is the primary source aquifer for the Cockatoo Creek, Spring Creek and Boggomoss (south) springs, while the Hutton Sandstone is the primary source aquifer for the Dawson River spring. There is some uncertainty around the water samples and results for the Boggomoss (north) spring. This confirms the groundwater conceptualisation developed for the EIS and used as a basis for the numerical modelling undertaken for the EIS.
4) The EIS groundwater model was calibrated to an inferred potentiometric surface due to a lack of observation bore data and issues with the available bore data quality derived from the GWDB. Comparison between the potentiometric surface from the model and the observed measurements from this field program show good agreement, consistent with the Australian Groundwater Modelling Guidelines (NWC, 2012).

The model was developed based on the traditional conceptualisation of well-defined aquifer and aquitard layers typically associated with the GAB. However, during the drilling program, distinction between regional-scale aquifer and aquitard units could not be made and high groundwater pressures and flows appeared to be associated with thin and discrete higher permeability zones within an essentially consistent lithological sequence of low permeable sediments. This means that the potential impact on the groundwater system from the dam is likely less than that presented in the EIS.

Vertosols were identified in alluvial material during the field program. These soils are often referred to as ‘black soils’ and characteristically crack open when dry and have very large water holding capacity when wet. These were not included in the EIS groundwater model. This means that the model may overestimate the induced recharge from inundation through the soils into the groundwater system. This means that the potential impact on the groundwater system from the dam is likely less than that presented in the EIS.

Field observations, anecdotal data and temporal groundwater level data were reviewed for the 2010-2011 floods. These field observations suggest that the hydrogeological constraints affecting spring flow and their persistence are reflective of a generally stable hydrogeological flow regime and a slow response to recharge, based on low permeability of the formations and the tightness of structure in the geology hosting the springs. This is consistent with the conceptualisation adopted in the EIS. It is also consistent with the relatively permeable modelled aquifer parameters of the Precipice Sandstone adopted in the EIS.

The numerical groundwater model was based on the best available data at the time of the EIS. The model shows good agreement with observed groundwater levels. Based on the hydrogeological observations from this field survey, the model is considered to provide a conservative estimate of the potential groundwater impacts of the dam. As such the existing model is considered to be appropriate for its intended use of assessing likely impacts on springs and existing users.

The above conclusions represent a refinement of the EIS hydrogeological conceptual model, not a revision of it. Overall, the results of this study confirm that the fundamental assumptions and conceptualisation presented in the EIS remain appropriate for assessing the impacts to the groundwater system from the Nathan Dam Project. The data collected as part of this study confirm the conceptualisation developed as part of the EIS. Furthermore, the results of this assessment indicate the initial numerical modelling undertaken during the EIS is likely to provide a conservative estimate (over prediction, but within realistic bounds) of groundwater impacts and remains suitable".

The independent peer reviewer concluded:

> *"Based on our review of the hydrogeological investigation and assessment methodology, our understanding of the literature incorporated into the desktop study and our evaluation of the SEIS report, it is RPS' view that the SEIS documentation sufficiently addresses the Terms of Reference and EIS comments and presents sufficient data to adequately evaluate risks to groundwater in the Nathan Dam study area".*

28.1.4.2. Assessment against the Recovery Plan

A national recovery plan for the GAB discharge spring wetlands has been adopted (Fensham *et al.*, 2010) and is the primary framework for the community's recovery. The overall objective of the recovery plan is to maintain or enhance groundwater supplies to GAB discharge spring wetlands, maintain or increase habitat area and health, and increase all populations of endemic organisms. With respect to this overall objective:

- the Project will enhance groundwater supplies to springs via increasing pressure on the aquifers;
- the Project will inundate 23 EPBC listed springs so the area of the community will decrease. It is uncertain if the increased pressure on springs above FSL will lead to any increase in habitat area though it is probable. This could then be interpreted as partly compensating for the area inundated below FSL though as the change cannot be quantified, SunWater has not formally included it as contributing towards mitigation or offsets. SunWater's offset strategy aims to protect currently unprotected springs and improve their health and this includes any increase in habitat area or new vents that result from increased pressure, and
- populations of endemic organisms will not be affected by the Project because no endemics are recognised from the impacted springs.

The relationship of the Project to the specific Objectives of the Plan is summarised below. There are a number of performance criteria and actions related to each objective but as they are often not relevant to the impacts of the Project, only those which are of relevance will be discussed.

Objective 1. *Enhance aquifer pressure and ensure flows from springs do not decrease (lower than natural variability).*

The Project does not propose to use GAB water or establish bores for extraction of GAB water during any phase of works. Dewatering during construction relates to shallow alluvial aquifers, or areas classified as recharge, rather than discharge so does not impact on the listed community. The Project will permanently increase aquifer pressure during operation (though it will still vary from spring to spring and from time to time). The Recovery Plan notes “high pressure at the discharge point generally conferring greater resilience to groundwater extraction in neighbouring areas”. This is interpreted as a benefit to the community. Further discussion on potential changes at springs as a result of increased pressure is provided below.

Section 15.2.3 of the EIS stated “The increase in discharge from existing Boggomoss springs is likely to either manifest as an increase flow out of the current spring area, an increase to the overall spring area, or both. In addition, it is also likely that an increase in the potentiometric surface of the underlying aquifers will result in new spring sites. The location of these new sites is likely to be controlled by similar processes as the current spring sites (i.e. fault controlled and thinning of the overlying aquitard).”

The potential increase in discharge from springs has been further assessed. The discharge of groundwater at a spring vent may be broadly described by Darcy's Law (refer to **Figure 28-7**):

$$Q = K\, i\, A$$

Where:

- Q = the discharge rate (m^3/day)
- K = the vertical hydraulic conductivity (m/day)
- i = the hydraulic gradient (in this case, the measured change in head divided by the vertical distance over which the head change occurs
- A = the cross sectional area of the aquifer (in the case of a spring vent this may be a variable combination of discrete fractures or fault planes and the strata between the confined aquifer and ground surface) through which water is released (m^2)

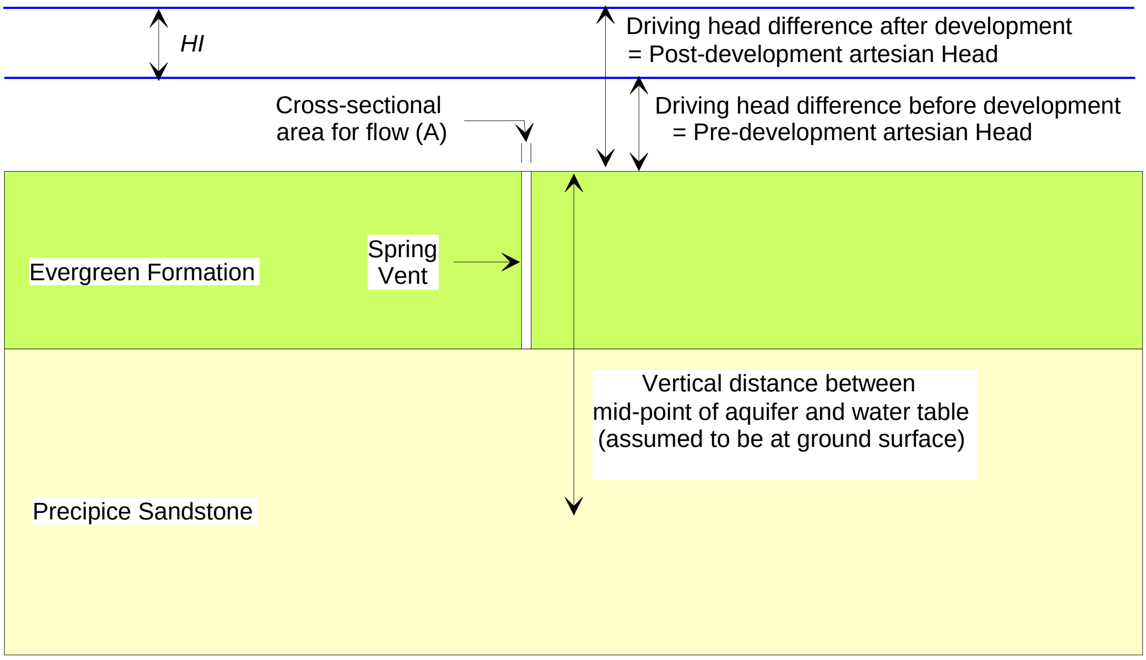


Figure 28-7 Components of Darcy Equation relating to Spring Flow

The percentage change in flow rate for a given change in artesian head in the Precipice Sandstone Aquifer (i.e. the rise in artesian head relative to the pre-development artesian head), based on the Darcy calculation described above, is shown in **Table 28-3**.

It is noted also that the change in flow rate is proportional to the change in water level, i.e. a 25% increase in artesian head will lead to a 25% increase in flow rate.

For discharge springs located outside of FSL, the maximum modelled increase in artesian head was 9.08 m, with a mean increase of 2.59 m and a median increase of 1.62 m (Appendix 15-F of EIS).

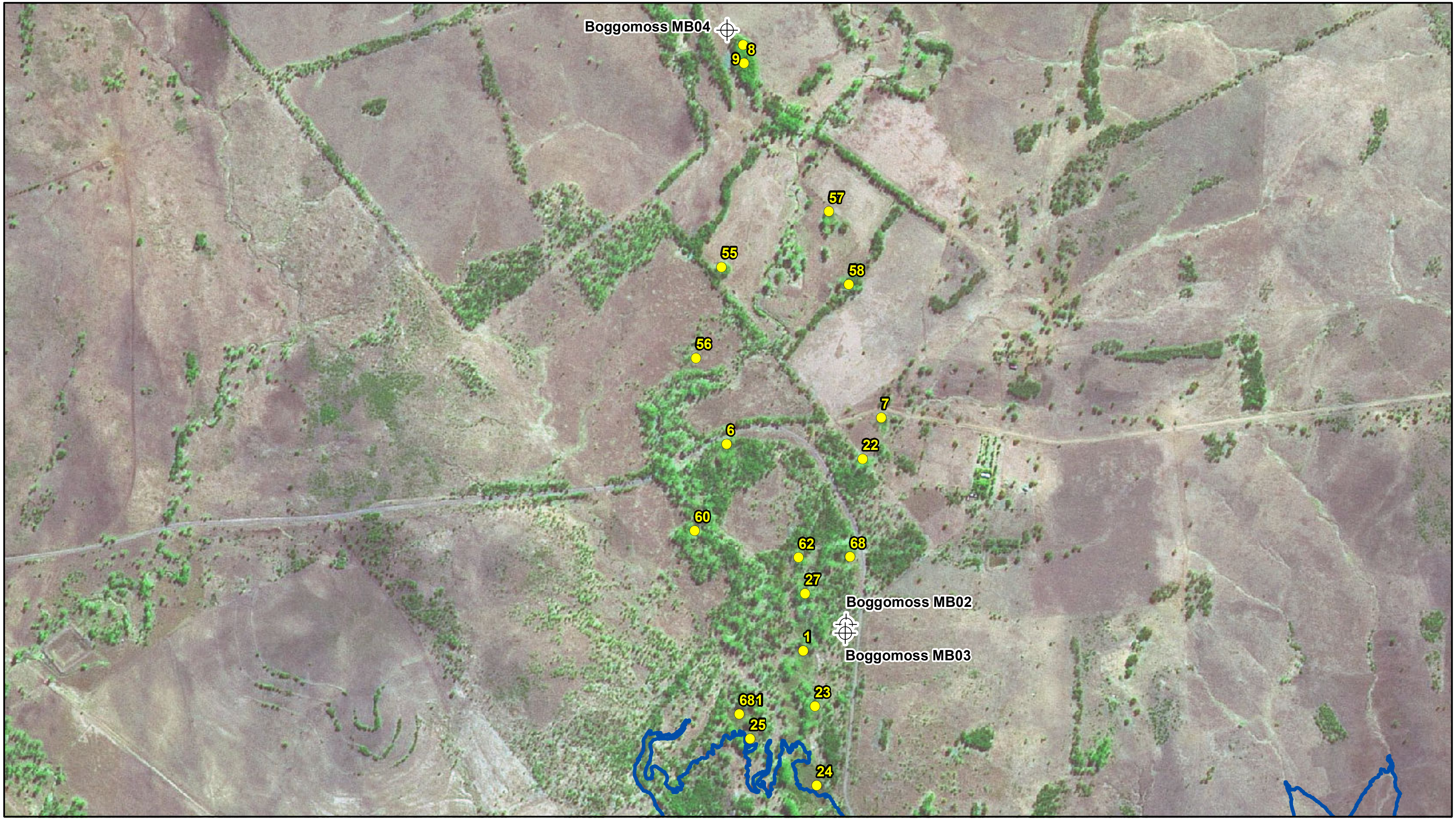
Table 28-3 Percentage change in Spring Flow Rate for a given Change in Artesian Head

Pre-Development Artesian Head (m)	Change in artesian head (m)						
	0.5	1	1.62	2	2.59	5	10
	Change in Flow Rate (%)						
2	25.0	50.0	81.0	100.0	129.5	250.0	500.0
5	10.0	20.0	32.4	40.0	51.8	100.0	200.0
10	5.0	10.0	16.2	20.0	25.9	50.0	100.0
15	3.3	6.7	10.8	13.3	17.3	33.3	66.7
20	2.5	5.0	8.1	10.0	13.0	25.0	50.0
30	1.7	3.3	5.4	6.7	8.6	16.7	33.3

From **Table 28-3** it can be seen that the most significant changes in flow rate will occur for situations where the pre-development artesian head is relatively low and the post-development change in artesian head is relatively high (e.g. for a pre-development artesian head of 2 m, a change (increase) in artesian head of 10 m would result in a 500% increase in flow rate).

However, for the mean and median increase in water level (2.59 m and 1.62 m respectively) the change in flow rate is likely to be more modest (depending of course on the initial artesian head). With respect to the potential increases in flow, the following observations are made:

- To the north of the Nathan Dam FSL, in the area of the Bogomoss and Dawson 6 spring complexes (**Figure 28-8**), the maximum modelled increase in Precipice Sandstone head is 2.68 m with a mean of 1.27 m and median of 1.46 m. The closest monitoring bores to this location (Bogomoss MB02, MB03, MB04) have artesian heads ranging from approximately 12 to 15 m above ground level. Taking the lower of these artesian heads (12 m) and the highest modelled increase in Precipice Sandstone pressure (2.68 m) the maximum calculated increase in spring flow would be in the order of 22%.
- For springs down-gradient of the dam wall, the following observations are made with respect to potential changes in spring flow rate (**Figure 28-9** shows locations of features discussed below):
  - The closest discharge springs down-gradient of the dam wall are those within the Prices complex (e.g. Spring ID's 52, 67, 41 and 40). The modelled increase in artesian head for the Precipice Sandstone at these springs ranges from 6.26 to 9.1 m (Appendix 15-F of the EIS). At these sites the ground elevation is between approximately 177 and 181 mAHD (depending on the site);
  - The closest groundwater bore for which artesian heads have been measured (Spring Creek PB01) recorded a shut-in pressure of 83kPa (approximately 8.5 m artesian head) (SunWater pers. comm.). Therefore, allowing for casing stick-up, the artesian head at this site is approximately 9 m. The ground level at PB02 is approximately 197 mAHD, meaning that the potentiometric surface at this location is at approximately 206 mAHD.
  - Assuming that the potentiometric surface is similar at both sites, the artesian head at the location of the Prices Spring Complex could be in the order of 25 to 30 m. Assuming an artesian head at the lower end of this scale (25 m) and a modelled increase in artesian head of 9.1 m, the increase in flow at this site would be in the order of 36%. Even allowing for a situation where the current artesian head at these sites is lower than predicted above (say 10 m), an increase in artesian head of 9.1 m would represent an increase in flow rate of no more than approximately 90%.



LEGEND

Location Where Artesian Pressure Read

Spring Location and ID Number

Full Supply Level (183.5m AHD)

Projection: GDA94 Zone 56

Figure 28-8

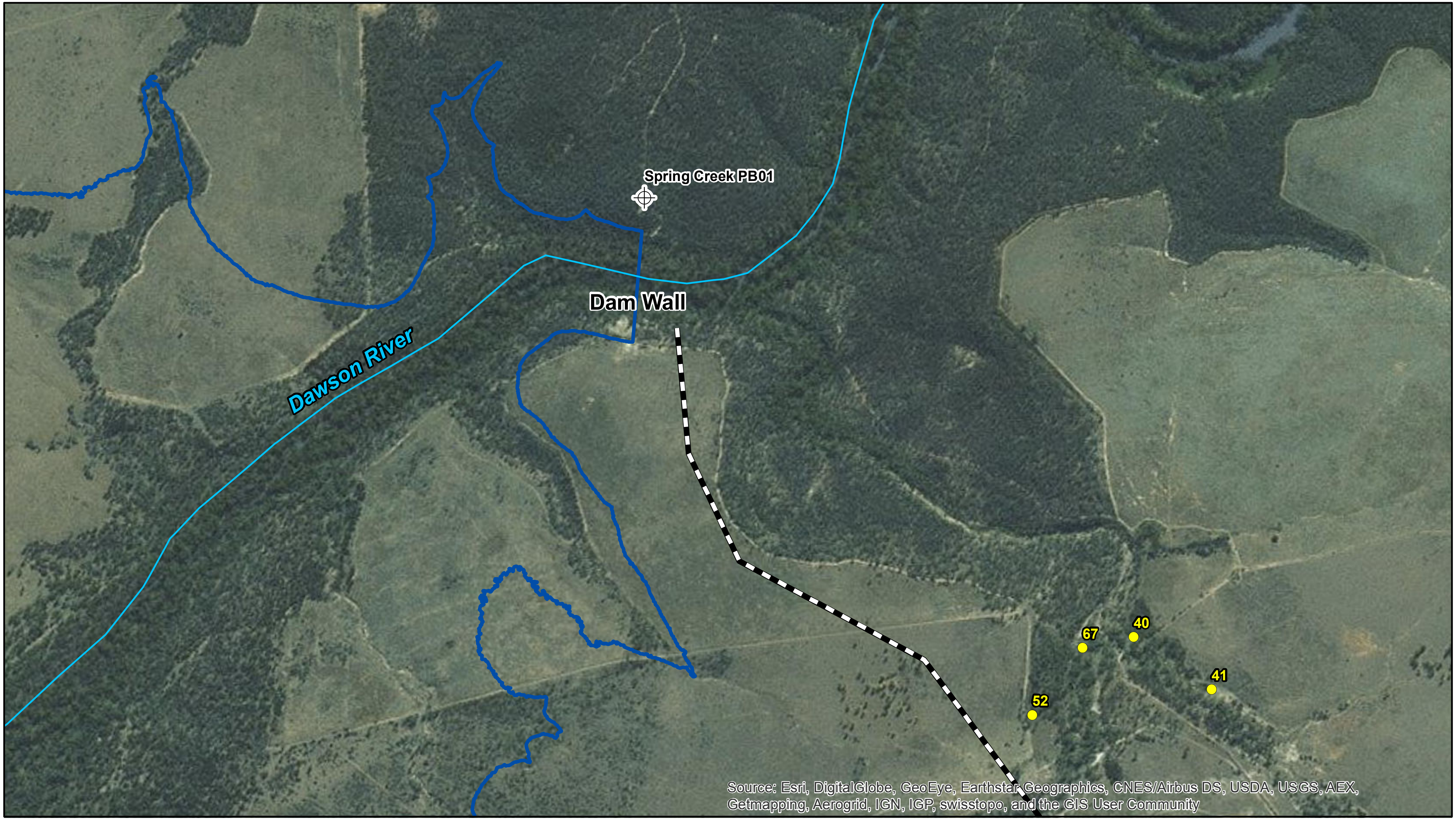
0 125 250 500 Meters N

Scale 1:18,000 (at A4)

SKM SunWater Making Water Work

ADDITIONAL INFORMATION TO THE NATHAN DAM EIS

Location of Springs Relative to Monitoring Bores MB02, MB03 & MB04



LEGEND

⌖ Location Where Artesian Pressure Read

● Spring Location and ID Number

Pipeline Route

Full Supply Level (183.5m AHD)

Projection: GDA94 Zone 56

Figure 28-9

0 125 250 500
Meters
N

Scale 1:15,000 (at A4)

SKM SunWater Making Water Work

ADDITIONAL INFORMATION TO THE NATHAN DAM EIS

Location of Springs Relative to Bore Spring Creek PB01

Appendix 15-F of the EIS and the above discussion present the change in potentiometric pressure modelled with the dam continuously at FSL (Full Supply Level of 183.5m AHD). In viewing these results it should be noted that it produces worse results (greater levels of change) than reality because the dam is predicted to be at or above FSL for about 7% of the time. The potentiometric pressure would decrease as the dam water level dropped to the minimum operating volume of the dam storage which is at 170 m AHD.

Appendix B15 of the AEIS notes “The observed groundwater behaviour during and following the 2010-2011 floods (showing an increase in groundwater elevation up to 10 m) suggest that during periods where the dam is at lower levels, groundwater levels will also lower and may return to pre-inundation levels. This further suggests that the potential impacts to springs presented in the EIS are likely to be over-estimated.” It would also be expected that smaller floods would cause smaller changes in the groundwater levels. Groundwater levels and spring discharges will therefore fluctuate once the dam is in place, as they do now.

Based on the above assessment, it is suggested that the maximum increases in spring discharge that are mentioned in the EIS are likely to be outliers, with the average increase in flow to the springs likely to be significantly lower (as calculated above).

Appendix B15 and Section 15.3.1 of the AEIS also note that like all models it is not a perfect representation of the real world but “the model has provided a reasonable estimate of hydraulic head which is consistent with the Australian Groundwater Modelling Guidelines (NWC, 2012) and accepted industry standards”.

Table 28-4 shows the estimated flow rate and wetland area of nearby springs above FSL (taken from the Queensland Springs Database). Note that another 13 EPBC springs in the Springsure supergroup are not included because they are beyond the area of influence of the Project.

Table 28-4 Spring estimated flow rate and wetland area

Spring	Estimated flow rate (L/min)	Wetland area (ha)
Dawson 6: 1	11.7	0.16
Dawson 6: 5	69.5	0.55
Dawson 6: 6	20.7	0.23
Dawson 6: 22	6.1	0.10
Dawson 6: 23	13.3	0.17
Dawson 6: 24	132.8	0.86
Dawson 6: 25	5.0	0.09
Dawson 6: 27	2.5	0.05
Dawson 6: 31	122.7	0.82
Dawson 6: 60	5.5	0.09
Dawson 6: 681	22.5	0.25
Dawson 8: 26	0.6	0.02
Dawson 8: 28	0.3	<0.01
Boggomoss 5: 7	9.3	0.13
Boggomoss 5: 8	13.4	0.17
Boggomoss 5: 9	1.3	0.03

Spring	Estimated flow rate (L/min)	Wetland area (ha)
Boggomoss 5: 10	2.2	0.05
Boggomoss 5: 15	1.2	0.03
Boggomoss 5: 55	1.8	0.04
Boggomoss 5: 56	2.5	0.05
Boggomoss 5: 57	36.6	0.35
Boggomoss 5: 58	2.9	0.06
Boggomoss 5: 62	0.5	0.01
Boggomoss 5: 68	3.0	0.06
Cockatoo: 64	34.2	0.33
Cockatoo: 65	3.7	0.07
Cockatoo: 66	0.4	<0.01
Cockatoo: 319	3.8	0.07
Cockatoo: 320	0.4	0.01
Cockatoo 321	0.4	0.003
Cockatoo: 684	0.1	<0.01
Prices: 40	2.3	0.05
Prices: 41	2.9	0.06
Prices: 52	3.4	0.06
Prices: 67	1.8	0.04
Range Dawson 6	2.5-132.8	0.05-0.86
Range Boggomoss	0.03-+36.6	0.03-0.35

The seven springs in the Cockatoo Creek complex are not affected by changes in pressure at FSL so no change in flow would be expected. The two Dawson 8 springs show increases around median levels. These locations are the most distant and / or up-flow from the deepest parts of the water storage and as water storage levels dropped the flow at these springs would be expected to return to natural levels.

There is a strong linear relationship between flow rate and wetland area (r=0.987 using the data above) suggesting that if the flow rate from the springs increased, so would the area of wetland. The extent of change would vary depending on local topography and soil such that additional flow at springs within or near watercourses would likely discharge more rapidly to the watercourse rather than lead to significantly expanded wetland area. This is likely for Price Creek springs and a number of springs within the Dawson 6 and Boggomoss complexes which are within or near Boggomoss Creek. Other springs in the Boggomoss complex are in a broader black soil valley so would be more likely to show a down gradient expansion of the soak area rather than run-off. Any increased ponding would be dependent upon specific local conditions and only likely at sites where significant increases in flow rate occurred.

As shown in **Table 28-4**, the range of current flow rates estimated for the springs is wide (covering four orders of magnitude at the scale used in the database), but the majority show relatively low rates while only a few show relatively high rates (e.g. springs 24, 31 and 5). Springs in the Boggomoss 5 complex show particularly low flow rates. For example 8 of the 11 springs show flow rates (<3L/min) lower than all but one of the Dawson 6 springs. The estimated maximum change in flow rates in these complexes is about 22% so the post-dam flow rates for the majority of springs will be little different to now (viz; a 22% increase on a very small number is still a very small number) and while an increase in wetland area may occur, at these low levels of change it is unlikely to be discernible from normal levels of temporal variation.

For those springs with a currently relatively high estimated flow rate, depending on the local landform there is greater potential for increased ponding and / or expansion of the wetland area.

SunWater reviewed the Queensland Springs Database to evaluate if springs with higher discharge were more floristically diverse. It appears there may be a relationship though this could be a simple relationship with the greater wetland area and also appears influenced by other factors such as any protection from cattle grazing and proximity to intact vegetation. That is, if the spring is buffered by intact vegetation it tends to have higher diversity than if it is isolated within cleared grazing areas. There did not appear to be any obvious relationship with the presence of threatened species (as there are only two) or truly disjunct species.

The maximum extent of predicted change in water level other than at Prices Creek is an increase of 3.62 m (Appendix 15-F of the EIS). Section 15.3.1 of the AEIS notes two bores were in place near the proposed dam wall which captured the impact of the December 2010 – January 2011 rainfall events and associated large floods, with the data showing an increase in groundwater elevation up to 10 m, likely driven by the resulting recharge pulse during the flood event. The nearest modelled springs to these bores are Prices Creek so the extent of change as a result of the water storage is similar to or less than that naturally experienced by the springs (though they would normally return to baseflow levels after a flood but will remain higher for longer as result of the weight of water in storage). Similarly springs positioned higher in the landscape would experience a change during and after flooding but probably not to the extent observed at these bores as they were positioned close to the river.

Several springs above FSL are and will remain occasionally impacted by natural flooding, either related to the nearby watercourse or the Dawson River. Flooding can physically affect springs through scouring or deposition of sediment, removal of debris and organic matter or deposition of flood debris, thus altering the path of flow from the spring. The same outcome could result from pig rooting or cattle pugging and mask the effect of any small scale changes in spring discharge.

The EIS conclusion with regard to the possible changes in springs as a result of increased groundwater pressures was restricted to broad comments because there is both a significant variation in the form and function of existing springs and the extent of potential change varies with location of specific springs. Despite this, the following is considered a reasonable interpretation of likely outcomes:

- The majority of Springsure super group springs above FSL are likely to show no or very little change relative to baseline conditions so no change is expected to spring values at these sites as a result of the Project.
- For the springs which experience a more significant increase in pressure and water level, this increase will vary over time as floods or droughts occur and dam water storage levels change. There will still be climatic periods of relative wet or dry and the springs will respond to these as they do now.
- During periods of more sustained dry weather, spring discharge will be most similar to current levels.

- During periods of more sustained higher pressure the increased discharge may manifest as:
  - Increased channelled flow to a nearby watercourse (likely at Prices Creek and springs closest to Boggomoss Creek)
  - Increased ponded area and / or wetted area surrounding the spring
  - Increased mound size.
- An increase in ponded area would favour fully aquatic plant and animal species and possibly lead to greater visitation by waterbirds. Species currently present at the springs or at nearby springs or watercourses would be most likely to inhabit the space. This is not viewed as detrimental to spring values unless colonisation by weed species was to occur.
- At most vegetated springs there is a transition from wetter areas near or surrounding the mound (often in a "moat") to drier areas on the margins or the extent of the soak. Wetter areas are favoured by wetland plants such as sedges and rushes while the margins are suited to ferns, woody shrubs, trees and grasses. An increase in water availability and the extent of the soak area would likely favour wetland species at the expense of woody species though the woody species would likely colonise the newly created margin of the soak. That is, the vegetation transition from wetter to drier areas of the spring would still be present but it would migrate from its current extent to an expanded extent. This would be a gradual process affected by natural spring dynamics, climate, flooding, dam water levels and other non-associated factors such as fire or access by stock or feral animals.
- As the discharge will be drawn from the same aquifer as now and water quality of the discharge relates to the long period of time over which the water has passed through the rock layers and the GAB, no change to the water quality of the discharged water is expected.
- Spring endemic species exist at nearby springs above FSL (or below the dam). Cockatoo Creek springs will not be affected by increased pressure, and Prices Creek, while experiencing increased pressure, is predicted to show little change in spring physiology.
- Similarly there is only one species associated with springs which is also an EPBC listed threatened species and is present at the springs (*Arthraxon hispidus*, Hairy Joint Grass) and it prefers the border of the wetland and will likely be suited to the changes which are predicted.
- The NC Act threatened *Thelypteris confluens* or Swamp fern, prefers permanently swampy areas so would not be adversely affected the predicted changes.
- Those species which represent isolated populations (giving springs a conservation category ranking of 2) comprise a range of sedges, forbs, herbs and grasses with a variety of habitat preferences but primarily they are associated with the spring because of a preference for wetter habitat and as such are likely to be favoured by the predicted changes.
- While unlikely, if it was determined that increased flow was causing detrimental changes to the ecology of a spring site, the "excess" water could likely be drained to an appropriate area of use or discharge.

With respect to how the changes identified above may affect spring values or the listed community, the values of the community relate to endemism, supporting threatened species associated with springs and supporting disjunct of isolated populations of species. The only attribute of the springs above FSL which will be impacted by the project is the rate of discharge from the spring. As noted above, important abiotic attributes such as water quality would not be expected to change as a result. Drawdown of springs, or reduced pressure, is the key existing impact and ongoing threat to springs and on the community as identified in the listing documents. The impact considered here is the reverse, that is, increased pressure. While the Springsure group is relatively little affected by drawdown compared to some other groups, water is extracted from GAB aquifers within the region so it is possible that pressures have been reduced below natural levels and the impact of the project could be interpreted as positive on this basis, however this cannot be quantified.

When comparing the extent of change to the current baseline as noted above, most springs of the group (and therefore the community as a whole) are either not affected or affected only to a minor extent and as such, no change in values would be expected. Any change therefore relates only to a small proportion of occurrences of the community.

For those springs which are likely to see a more significant increase in pressure, the discussion above suggests that it is likely that the wetted area associated with the spring would increase, given the strong correlation between discharge and wetted area. This provides greater opportunity for those species which are members of the community to inhabit the space and this is viewed as a positive outcome.

The discussion above suggests for a species which is a member of the community, that as a result of the predicted changes to spring area it is very unlikely that the area would become so unsuitable that the species would not be able to persist. It is more likely that the species complement at a site will remain the same (or within the bounds of natural variation) but the relative composition may alter to an extent. As such no significant impact on threatened or disjunct species or any member of the community is predicted as a result of the change in pressure.

In summary, while change will occur at a proportion of springs, the direction of change is likely to be positive. Risks of negative change relate essentially to “too much water” and can potentially be mitigated by physical intervention as noted above. Other potentially negative changes relate to colonisation by weed species or greater susceptibility to disturbance by feral animals. SunWater has committed to development of management plans related to these threats and to implement those plans at sites which will be protected by tenure based mechanisms.

Objective 2. *Achieve appropriate tenure based security to protect against future threatening processes.*

SunWater proposes establishment of such tenure for most local springs outside the inundation area and then instituting appropriate management of those springs to ensure their protection and ongoing health, which will include rehabilitation where necessary. As an example, the existing Boggomoss Nature Refuge (Figure 28-6) includes 7 springs but there are a further 14 in close proximity that are not formally protected.

Objective 3. *Minimise impact of stock and feral animal disturbance and manage total grazing pressure.*

At each of the sites for which SunWater will be establishing secure tenure, a management plan will be developed that specifically addresses stock, grazing pressure and feral animals in order to minimize impact.

Objective 4. *Minimise the threat of exotic plants and aquatic animals and reduce their effects.*

At each of the sites for which SunWater will be establishing secure tenure, a management plan will be developed that specifically addresses exotic plants and aquatic animals in order to minimize impact.

Pennay *et al.,* (2012) noted "The greatest threat to spring wetlands from exotic plants is from Para grass (Urochloa mutica)". The species was recorded from five sites within the Boggomoss 5 complex, four of which will be inundated by the water storage. SunWater will use appropriate herbicide to kill the plants at these four sites prior to the storage filling and will take active steps to eradicate the plant from the one remaining site.

Objective 5. *Ensure that impoundments do not degrade spring values.*

The single related Performance Criteria is: *The conservation value of GAB discharge springs are not negatively impacted by impoundments*.

The related Action (5.1) is: *Ensure that the impact of impoundments on spring values are properly considered in environmental impact assessments*.

It further states *"Impoundments can cause the inundation of spring wetlands, therefore careful consideration should be given to the environmental impacts of an impoundment. Environmental impact assessments should ensure that affects resulting from impoundments will not cause the extinction of endemic species or the loss of other significant natural spring values".*

SunWater considers that GAB springs have been properly considered in the EIS process. The EIS process is based on a TOR that was developed in accordance with appropriate procedures and included specific reference to GAB springs. The threatened community was described in Section 28.3.4.2 and the impacts were assessed in section 28.4.2.2 of the EIS.

Table 28-6 uses the departments Significant Impact Guidelines to assess impacts.

Communication from DoE dated 1 September 2011 clarified that "the values of this ecological community relate to the community of native species dependant on the groundwater discharge rather than the number and location of the specific springs". In line with the basis of the conservation ranking applied to the community in the Recovery Plan, the spring values relate to endemism, support of listed threatened species or representing isolated or disjunct populations of a species. **Table 28-5** presents the values of springs potentially impacted by the Project and those nearby springs which are not impacted. The data is drawn directly from the Queensland Springs Database (accessed November 2015). "Condition" relates to excavation, pig or stock damage and is recorded in the database on scales of 0-4 or 0-3 (being none, minor, moderate or major). There are a further 13 springs within the Springsure group which have not been classified as "nearby" and are not evaluated in the table. In the discussion below the table it is noted that the number of springs with isolated populations was conservatively over-estimated when compared with information from a more complete data set.

Table 28-5 Comparison of values of impacted and nearby non-impacted springs

Spring ID	Wetland area ha	Threatened or isolated populations	Condition notes	Conservation ranking of vent
IMPACTED				
Dawson 6: 4	3.53	*A. hispidus*	Minor pig	1b
Dawson 6: 30	0.04	*A. hispidus*	Minor pig	1b
Dawson 6: 32	0.34	*A. hispidus*	Minor pig	1b
Dawson 6: 42	0.11	Isolated population	Minor stock	2
Dawson 6: 43	0.01	Isolated population	Major stock	2
Dawson 6: 59	0.08	*A. hispidus*	_	1b
Dawson 8: 38	0.48	Isolated population	Moderate excavation	3
Boggomoss 5: 2	0.1	Isolated population	_	2
Boggomoss 5: 3	0.04	Isolated population	Minor pig and stock	2
Boggomoss 5: 11	0.11	Isolated population	Minor pig	2
Boggomoss 5: 12	0.03	_	Minor pig, major stock	3
Boggomoss 5: 13	0.03	_	Minor pig, major stock	3
Boggomoss 5: 14	0.03	_	Major pig	3
Boggomoss 5: 29	0.01	Isolated population	Minor excavation	2
Boggomoss 5: 33	0.25	Isolated population	Minor excavation	2
Boggomoss 5: 37	<0.01	_	_	4
Boggomoss 5: 44	0.13	Isolated population	_	2
Boggomoss 5: 53	0.02	Isolated population	_	2
Boggomoss 5: 54	<0.01	Isolated population	Minor stock	2
Boggomoss 5: 61	0.14	Isolated population	_	2
Boggomoss 5: 63	0.03	Isolated population	Minor pig and stock	2
Boggomoss 5: 683	0.02	Isolated population	Major pig and stock	2

Spring ID	Wetland area ha	Threatened or isolated populations	Condition notes	Conservation ranking of vent
Boggomoss 5: 691	0.05	Isolated population	Moderate stock	2
TOTAL	**5.59**			
NEARBY NON-IMPACTED SPRINGS				
Dawson 6: 1	0.16	*A. hispidus*	Minor pig and stock	1b
Dawson 6: 5	0.55	*A. hispidus, T confluens*	_	1b
Dawson 6: 6*	0.23	*A.hispidus*	Minor pig and stock	1b
Dawson 6: 22*	0.10	*A.hispidus*	Minor pig and stock	1b
Dawson 6: 23*	0.17	*A. hispidus, T confluens*	Minor stock	1b
Dawson 6: 24	0.86	*A.hispidus*	Minor pig and stock	1b
Dawson 6: 25	0.09	*A.hispidus*	_	1b
Dawson 6: 27*	0.05	*A.hispidus*	Minor pig and stock	1b
Dawson 6: 31	0.82	*A.hispidus*	Minor pig	1b
Dawson 6: 60	0.09	*A.hispidus*	Minor pig and stock	1b
Dawson 6: 681	0.25	*A.hispidus*	_	1b
Dawson 8: 26	0.02	_	_	3
Dawson 8: 28	<0.01	_	_	3
Boggomoss 5: 7	0.13	*A.hispidus*	Minor stock	1b
Boggomoss 5: 8	0.17	_	Minor pig	2
Boggomoss 5: 9	0.03	Isolated population	Minor pig	2
Boggomoss 5: 10	0.05	Isolated population	Minor pig and stock	2
Boggomoss 5: 15	0.03	Isolated population	Major stock	2
Boggomoss 5: 55	0.04	Isolated population	Minor stock	2
Boggomoss 5: 56*	0.05	Isolated population	Minor pig and stock	2
Boggomoss 5: 57	0.35	Isolated population	Minor stock	2
Boggomoss 5: 58	0.06	Isolated population	Mod stock	2
Boggomoss 5: 62*	0.01	Isolated population	Minor stock	2
Boggomoss 5: 68*	0.06	*A.hispidus*	Minor pig and stock	1b
Cockatoo: 64	0.33	*E. carsonii, M. artesium*	Heavy excavation and stock	1b
Cockatoo: 65	0.07	*E. carsonii, M. artesium*	Heavy stock	1b
Cockatoo: 66	<0.01	_	_	3
Cockatoo: 319	0.07	*M. artesium*	Moderate stock	1b
Cockatoo: 320	0.01	*M. artesium*	Major stock	1b

Spring ID	Wetland area ha	Threatened or isolated populations	Condition notes	Conservation ranking of vent
Cockatoo 321	0.003	*E. carsonii, M. artesium*	Major stock	1b
Cockatoo: 684	<0.01	_	Moderate stock	3
Prices: 40	0.05	*E.carsonii*	Minor pig, mod stock	1b
Prices: 41	0.06	*E.carsonii*	Minor pig, mod stock	1b
Prices: 52	0.06	*E.carsonii*	Minor stock	1b
Prices: 67	0.04	Isolated population	Minor stock	2
TOTAL	**5.07**			

Note: * denotes the spring is within the Boggomoss Nature Refuge

Impacted springs have conservation rankings of between 1b and 4. Non-impacted springs have conservation rankings of between 1b and 3.

There are no Springsure group EPBC listed springs with a category 1a conservation ranking (Pennay *et al.*, 2012) and this is appropriate because it only applies to springs with endemic species which are not known from any other location. However the supergroup does include some non-EPBC springs which have a 1a ranking (Rock art, Major Mitchell and Carnarvon Gorge) and they are also not impacted by the project.

No spring endemic species are known from springs which will be impacted by the Project so no endemic species will become extinct as a result of the Project.

Appendix 2 of the Recovery Plan lists species endemic to discharge spring wetlands and the springs database (Fensham and Fairfax 2012; a background document to the Recovery Plan) confirms the endemic *Eriocaulon carsonii* (Endangered under EPBC Act and NC Act) and *Myriophyllum artesium* (Endangered under NC Act) as being present in the Cockatoo Creek and Price Creek complexes within the Springsure group. Cockatoo Creek will not be impacted in any way by the Project while Price Creek will not be physically disturbed but will experience increased water levels once the dam is operational. The Recovery Plan also identifies habitat critical to the survival of *Eriocaulon carsonii* and this is not within the area of the Project. SunWater proposes to use these areas to assist in achieving the outcomes of Objective 2 (protect via appropriate tenure).

The only EPBC listed threatened species included within the community at impacted sites is Hairy Joint Grass (*Arthraxon hispidus*; listed Vulnerable under the EPBC Act and NC Act) which is impacted at 4 sites. The species is present at thirteen non-impacted sites. As the species is known from springs outside FSL this value will not be lost to the community or from either spring complex so the conservation ranking of each complex will remain as it is now. Hairy Joint Grass is discussed above as a threatened species and in its own right it was concluded as not significantly impacted.

The springs database also lists the species as present at three other Springsure group recharge springs which are not affected by the Project. The species is also not restricted to springs or indeed to Australia.

The critically endangered Boggomoss Snail, *Adclarkia dawsonensis*, has been recorded at site 3 within the Boggomoss 5 complex and that site will be inundated by the water storage. (The site is otherwise known as

Boggomoss 14). Within Pennay *et al.,* (2012) the presence of the species is not included in Table 6, Table 13 or Appendix F, tables which relate to EPBC Act listed species associated with GAB spring wetlands or to the basis of the conservation ranking of spring complexes. Pennay *et al.,* (2012) notes that the Boggomoss Snail is not aquatic and was found "adjacent" to a spring. This has always been the case and is why the species is not dependent on the spring hence is not part of the listed community. This conclusion is supported by the lists of endemic or threatened fauna associated with springs (in the Recovery Plan and in Pennay *et al*., 2012) because they only include aquatic species such as fish, crustaceans and aquatic snails. Similarly the Recovery Plan notes "with few exceptions, the non-endemic animals appear to be widespread, being found in, or associated with, other water bodies". The snail is further removed from this discussion because it is a terrestrial species and not associated with the water body. The Recovery Plan also notes that many bird species and grazing mammals (which are terrestrial species) use the spring wetlands. Many of these would likely be on threatened species lists but they are not used when determining the conservation ranking of a spring wetland. The Boggomoss Snail is also in this category. The EIS noted that the inclusion of the snail in tables in the Recovery Plan was probably an error and the recent changes to other relevant documents confirm this view.

The NC Act listed *Thelypteris confluens* is also noted as occurring at two sites in the Dawson River 6 complex and these sites are above FSL so not impacted by inundation associated with the Project.

SunWater's approach to the threatened species which are or may be found at springs impacted by the Project is to address them as listed threatened species in their own right. Readers are referred to assessments of Boggomoss Snail and Hairy Joint Grass contained in the EIS or updated in this document.

While the springs database suggested 36 species could be regarded as disjunct or isolated populations at the local springs, (18 of which occur at sites which will be impacted), analysis using the Atlas of Living Australia shows the latter number as seven. The Herbarium (Laffineur pers. comm. August 2016) has since confirmed that one of these species *Laportea interrupta* was mis-identified and the specimen was probably that of a weed. The database was updated as a result of SunWater's enquiry. The remaining species are:

- *Arthraxon hispidus*
- *Eleocharis tetraquetra*
- *Fimbristylis tetragona*
- *Salomonia ciliate*
- *Stylidium rotundifolium*
- *Wahlenbergia stricta subsp. alterna.*

All of these species occur on more springs above FSL (i.e. springs which are not impacted) than below FSL so the isolated nature of the population will not be lost at the complex or community level. All species will still be present within the same spring complexes if the project proceeds and the value of these disjunct species will not be lost to the complexes, the Springsure group or the community as a whole.

As such, most of the springs listed in **Table 28-5** with a conservation ranking of 2 should actually have a ranking of 3 and therefore not be considered as of high biological value. Seven impacted springs support populations of species which could be regarded as disjunct using the Atlas. Of these, four also contain *Arthraxon hispidus* so have a conservation ranking of 1b (springs 4, 30, 32 and 59). Hence, only three of the category 2 springs are additional to these and could be regarded as having high biological value (springs 29, 42 and 43).

In summary:

- SunWater has properly considered the potential impact on springs in the EIS (including the SEIS).
- No spring endemic species will become extinct as a result of the Project or will be affected in any way.
- No other natural spring values (threatened species or isolated / disjunct species) will be lost as a result of the Project and the conservation rankings of all affected complexes will remain unchanged.

As such, the Project does not conflict with this objective.

Objective 6. *Maintain populations and improve habitat for endemic organisms where required using monitoring and adaptive management.*

As noted above, the Plan does not recognise any spring endemic organisms as present in those springs which will be impacted however monitoring and adaptive management of springs outside the inundation area is part of the Projects approach to managing springs.

Objective 7. *Engage custodians in responsible management of springs.*

SunWater and their property lessees will become custodians of springs on land purchased for the Project. As a result, the management approaches to springs advocated in the EIS will be undertaken on those properties. Cultural Heritage Management Plans are being developed for the Project in consultation with the endorsed Aboriginal parties.

Objective 8. *Develop community education and extension programs.*

The Project does not include any specific actions in this regard but given its proximity, and particularly that of the northern recreation area near the current Nature Reserves, it is highly likely that at least spring interpretive signage would be erected at the recreation area.

Objective 9. *Provide clarification and further information to the current EPBC listed ecological community to aid identification and responsibilities pertaining to the listing.*

The related performance criterion is that "Stakeholders, including land managers, have a clear understanding of the type or springs included within the definition of the ecological community". The Project does not conflict with this objective and it is SunWater's view that the EIS process has contributed to the achievement of this objective.

Objective 10. *Co-ordinate the implementation and evaluation of recovery plans relating to GAB springs*.

The Project does not conflict with this objective and SunWater will seek the assistance of the Recovery Team (or the relevant group existing at the time) in developing the management plans related to each spring or area of springs for which it will obtain secure tenure.

In Queensland, the GAB discharge spring wetlands that are protected are listed as Of Concern Regional Ecosystems under the Vegetation Management Act (primarily RE 11.3.22 but also RE 11.10.14).

DoE requested that the springs be assessed in accordance with the Significant Impact Guidelines. That assessment is provided in **Table 28-6.**

Table 28-6 EPBC Act impact assessment on the community of native species dependent on GAB discharge springs

Criteria	Significance of Impacts	Mitigation and Offsets
Reduce the extent of an ecological community?	The community of native species will be directly impacted via inundation at twenty-three sites. These sites are not near the limit of the range of the community or of any associated endemic or threatened species. The extent of the community itself will not be reduced despite the number of springs being reduced.	The only direct mitigation possible is to translocate (via propagation or physical removal) any native species at the springs to nearby springs if they are not already present at those springs. Given the DoE Policy on translocation, SunWater suggests that this action should be undertaken with a focus on rehabilitating degraded springs within the proposed secure areas rather than relocating species to healthy sites which already have established communities. Indirect mitigation may be achieved through the increased groundwater pressure outside FSL, as a result of inundation, because it is likely to increase the size and possibly the number of GAB discharge springs (or vents). It is not possible to accurately predict the change in flow rate from spring vents so the extent of mitigation cannot be estimated. It is important to recognise the possiblity so that appropriate management measures can be taken and SunWater has commited to include any expanded area or new vents within protected areas. The health of the 35 nearby GAB discharge spring communities outside FSL, and any new vents which are identified, will be monitored to record any physical changes or changes in species composition. Impacts will be offset by broader application of the recovery plan actions including: 1) achieving appropriate security of local springs; and 2) developing management plans which address Recovery Plan actions for those springs (such as weeds, feral animals, grazing, fire).
Fragment or increase fragmentation of an ecological community?	GAB discharge spring complexes are currently largely independent from one another and the Project will not fragment them.	None required.

Criteria	Significance of Impacts	Mitigation and Offsets
Adversely affect habitat critical to the survival of an ecological community?	No habitat related to the community is listed on the Register of Critical Habitat maintained by DoE. The Recovery Plan does not identify habitat critical to the survival of the community per se though it does identify sites with exceptional values. None of the impacted springs are (correctly) included within that list. Appendix 3 of the Recovery Plan provides additional information on EPBC Act listed species associated with the community and identifies habitat critical to the survival of those species. None of those species are located within the project area nor is the identified habitat. The impact is at the local scale and will not affect the survival of the community at the regional or national level as the GAB itself will not be negatively affected.	Monitoring as above.
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for the community's survival?	Inundation will modify abiotic factors at the individual springs concerned and the extent of this impact is noted above. This extent of change will not affect the survival of the community per se nor will it affect the survival in the wild of any threatened or isolated species associated with those springs. Once the dam is operational, groundwater pressure will be modified and will result in increased discharge from some springs, an increase in wetted area associated with those springs and may also result in new spring vents. Abiotic factors such as water quality would not be expected to change as a result because water quality is based on a very long residence time within the GAB aquifers. These changes are not regarded as negatively affecting the survival of the community.	Monitoring as above.
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species?	The species composition at inundated springs will change substantially. However, the species present at these springs does not include endemic species, or threatened / isolated species that are not found in nearby springs. As such they would not be considered functionally important species.	Translocation of native species to appropriate nearby un-impacted springs as noted above. Monitoring as above.

Criteria	Significance of Impacts	Mitigation and Offsets
	The new or expanded springs above FSL will provide a variety of habitat that is likely to suit species in the local area. No substantial change in the species composition is predicted as a result of increased pressure at springs above FSL.	
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: ▪ assisting invasive species, that are harmful to the listed ecological community, to become established, or ▪ causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community?	While the number of springs will be reduced as a result of the action, as no endemic species or habitat critical to survival will be affected, the threatened species that occur at the affected springs also occur nearby in unaffected areas and a substantial number of nearby springs will not be directly affected, the quality or integrity of the local occurrence of the community is not considered to be substantially reduced. This is evidenced by the lack of change in conservation rankings of affected spring complexes before or after the Projects construction. The likely expansion of springs outside FSL and the presence of the water storage may assist the establishment of aquatic species (both native and exotic) around the wetland areas. The construction phase has the potential to increase the spread of weeds in the area. The Project will not introduce any fertilisers, herbicides or chemicals into the community and may reduce such impacts through removal of current agricultural land.	Weed management plans are included within both construction and operation EMPs. Weed management will also be a specific component of the management plans for offset areas.
Interfere with the recovery of an ecological community?	A specific analysis against the Recovery Plan is provided in text above the table. The Project does not conflict with the specific objectives or actions contained within the Recovery Plan.	Impacts on GAB discharge springs will be offset as noted above. Management Plans associated with offset areas will specifically address objectives of the Recovery Plan. The net outcome targeted is an improvement in the health and understanding of local springs.

Offsets for this community

A number of submissions questioned the availability of appropriate offsets for the impacted community but generally related that to the assumption that a number of springs would be required as the offset. Communication from DoE dated 1 September 2011 clarified that “the values of this ecological community relate to the community of native species dependant on the groundwater discharge rather than the number and location of the specific springs”. Offsets for flora or fauna species or for communities is usually based on area and quality of habitat and a measure of ecological equivalence. The QLD Springs database identifies an area of wetland associated with each spring, provides a conservation ranking and provides information on the existing condition.

The database has been used to develop a “Habitat score” as a possible measure of equivalence and is based on the “Conservation ranking” and condition of springs. SunWater intends to provide the necessary offsets via appropriate tenure and management arrangements of springs that are not directly impacted by the Project. The appropriate means of providing offsets will be discussed with DoE and a proposed strategy is included as **Appendix B1-B**.

28.1.5. Assessment of impact as a result of changes to the pipeline route and length

Part C of the AEIS describes changes to the pipeline route as a result of either terminating at Warra rather than Dalby and having constructed the Nathan to Wandoan section as part of the separately approved Woleebee to Glebe Weir Project.

Impacts to Brigalow have been reduced to 0.4 ha. The likelihood of impact on *Acacia curranii* (V) has been commensurately reduced as it is associated with brigalow. The species was originally assessed as a Likely occurrence (Table 28-8 of the EIS) in suitable habitat near Gurulmundi but any impact was determined as not significant (Table 28-21 of the EIS).

The “Possible” occurrence of *Digitaria porrecta* (E) and “Unlikely” occurrence of *Thesium australe* (V) (Table 28-8 of EIS) in the Native Grassland ecological community (E) in the southern most extent of the pipeline near Macalister was also noted, including in Figure 28-12 and Figures 3a and 3b in Appendix 10b of the EIS. The EIS noted 0.07 ha of Native Grassland community within the pipeline corridor but assumed it could be avoided by a minor realignment. Truncation of the route near Warra (north of Macalister) removes that section of the pipeline so the risk of occurrence of the species or the community is now considered minimal.