ATTACHMENTS

A. Dr Lee Benson – Summary - Review of scientific reports released as part of the Northern Basin Review

B. Dr Lee Benson - Review of reports related to fish and flows in the Northern Basin.

C. Dr Lee Benson - Review of Waterhole refuge mapping and persistence analysis in the Lower Balonne and Barwon–Darling rivers

D. Dr Lee Benson - Review of the science behind the waterbird breeding indicator for the Narran Lakes.

E. Dr Lee Benson - Review of Water Requirements for Key Floodplain Vegetation

F. Mr Owen Droop – Summary - Review of Scientific Reports released as part of the Northern Basin Review

ATTACHMENT A

EM
Ecology Management

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Mr Frank Deshon
President
Smartrivers

Re: **Review of scientific reports released as part of the Northern Basin Review**

Dear Frank

Smartrivers appointed EM to technically review scientific reports released as part of the Murray Darling Basin Authority's Northern Basin Review. Although the reports took years to develop and were substantial in nature, only limited time was available to undertake the reviews. EM reviewed the main relevant reports covering fish (3 reports), refuge waterholes, floodplain vegetation and waterbirds at Narran Lakes (2 reports) over a period of three weeks. As such the reviews have been prepared without any discussions with the authors or the Authority.

In summary:

Fish:

- the recommendations relate only to the Barwon-Darling. They are a classic example of an inappropriate use of a volume of water to solve an issue which could be better solved by other means (raising water to the level of snags instead of lowering snags to the water; drowning out weirs instead of fitting fishways).
- The conceptual hydrographs include a winter-spring pulse which cannot be sourced from most of the Queensland rivers because such a flow does not naturally occur.
- The hydrographs also include large flow pulses when the literature suggests only small pulses are required.
- The high and low uncertainty thresholds for the site specific flow indicators are set very conservatively and rarely conform to the general 60-80% criteria.
- However even under Baseline levels of water resource development, 3-4 of the 7 indicators already meet a 60% uncertainty target. Under current recovery two of the others may also meet that target. Similarly if the flow levels were adjusted only slightly nearly all criteria would likely be satisfied by existing conditions.
- The literature review confirms again that rivers in the Queensland part of the basin are healthier than those in the NSW part of the basin. The problems in the NSW tributaries are locally derived and unrelated to extraction in Queensland. Scientific or management experience from these areas or from the southern basin, which is also

much less healthy, should not be transferred to the Queensland tributaries because it clearly does not work.

Waterholes as refugia

- The modelled persistence of waterholes does not correlate well with that estimated by satellite image interpretation or visual assessment (Webb 2009). The reasons may include:
  - models used maximum waterhole depths which likely substantially underestimate actual maximum depths.
  - There are substantial waterholes in relic floodplain channels which were not included.
  - The no-flow criteria was actually <2ML/d, i.e. still flowing.
  - The modelled minimum persistence estimate is based on no-flow <u>and</u> no-rainfall but no evidence for the dual occurrence of those criteria over extended time periods is provided.
- "The 95% prediction interval appears to be quite large (±121 days)". This level of accuracy is not suitable for management purposes.
- Most of the reaches in the region are at very low or no risk of drying out.
- The occurrence of drying events, even in the modelling world, is rare and the volume needed to overcome it is low.
- The different possible water recovery scenarios made no difference to the results and the report rightly nominates management actions as an appropriate approach to overcome drying.

Waterbirds at Narran Lakes

- The reports are fundamentally flawed because the hydrologic definition of an "event" is essentially unrelated to the ecological outcome of waterbird breeding (particularly the initiation of breeding).
- The definition means an event starts earlier than any actual breeding stimulus and the event often ends well after successful waterbird chick fledging.
- Merging of events was acknowledged by the authors and along with the above leads to longer estimates of event duration and larger estimates of event volumes than are actually required for waterbird breeding.
- This leads to extreme recommendations regarding setting the minimum event duration as 275 days when accepted information suggests 140-168 days would be sufficient to allow the majority of non-colonially breeding waterbirds to complete their breeding cycles and raise chicks to independence. The time required for Straw-necked ibis is recommended as 73-94 days.
- When adjusted for the actual number of events successfully predicted from those which were recorded, the likelihood that either of the nominated thresholds (162,000 ML over 90 days or 18,000 ML/d for 10 days) could reliably predict waterbird breeding in their own right is about 50% or no better than a coin toss and certainly not as good as suggested by the authors.
- The authors focussed on the flows that have coincided with breeding events above their nominated thresholds but spent very little time on those events which occurred at lower flows or in fact were not related to a flow event at all (January 2010), despite

these events constituting nearly half of the Narran Reserve breeding events relating to one or other of the thresholds.

- In terms of relevance to the existing site specific flow indicators, Figure 36 of Merritt et al shows that the number of SNI breeding events predicted by the Decision Support System (using 114 years of IQQM output) in the Existing Recovery scenario is 75% of the without development scenario. This level is in excess of that often regarded as acceptable in water resource development (e.g. the much used 2/3rd natural rule of thumb), and close to the MDBC's figure of 80% as representing near natural.
- Further, increasing water recovery by 90GL (to the Northern Standard) only increased the proportion of breeding events to 78% (or by 2 events). A cost benefit analysis could not possibly support such increased recovery on this basis. Management would be better focussed on using small volumes to top up or finish off events as occurred successfully in 2008.

Floodplain vegetation

- The document makes only one conclusion with regard to the EWR. "In summary, following the recommendations of Roberts and Marston (2011) for floodplain vegetation in the Northern Basin is likely to result in maintenance of the key species in the long-term". And; "This review did not reveal evidence that the recommendations are inappropriate for the Northern Basin."
- Even the MDBA (2012) EWR documents for the Lower Balonne modified the targets set by Roberts and Marston to reflect local without development hydrologic conditions e.g. they substantially reduced the required durations of flood events because they simply did not happen naturally in this region.
- When mention is made of how new information or the views of experts compares with Roberts and Marston (2011) it is nearly always reflective of trees growing in a naturally drier environment where flooding is less frequent, less prolonged and summer-autumn dominant. This is clear evidence that the Queensland part of the Northern Basin is different.
- It appears Jon Marshall and the team have been doing a lot of work over recent years which finally shows the Northern Basin is different. This is particularly the case for Queensland rivers from the Moonie west. For example Marshall et al 2012 uses statements such as "Contrary to expectations based on the scientific literature" and "This reliance on terrestrial production is inconsistent with what has been found in studies elsewhere and runs counter to our hypotheses" and "The ecological responses to flooding in rivers of the northern Murray-Darling differed greatly from expectations built on studies from elsewhere. The results have fundamentally reshaped our understanding of the aquatic ecosystems in this region." Given such strong wording it is difficult to support Casanova's conclusion.
- "The water regimes outlined here for restoration of Good condition are necessary for the maintenance and functioning of floodplain vegetation". The target condition is probably based on the lack of a seed bank for Red Gum and the assumption that the trees need to be in good condition to respond to the next opportunity. However this is not natural as the trees survive Australia's drought / flood cycles and at the end of most droughts they would not be in Good condition. This basic assumption appears illogical.

- Overall the review failed to put the various reports into the context of the Northern Basin, leaving the way open for continued misinterpretation and inappropriate application of knowledge.
- This review is actually a backward step from the existing SFI's set by the MDBA other than noting that some documents are now showing that the Lower Balonne is different and that species here are possibly less reliant on river flooding than their southern counterparts.

Detailed reviews have been provided separately.

Regards,
Dr Lee J Benson (Director)

<u>ATTACHMENT B</u>

Review of reports related to fish and flows in the Northern Basin.

NSW Department of Primary Industries (2014). *Fish and Flows in the Northern Basin: responses of fish to changes in flow in the Northern Murray-Darling Basin – Literature Review*. Final report prepared for the Murray-Darling Basin Authority. NSW Department of Primary Industries, Tamworth.

NSW Department of Primary Industries (2015). *Fish and Flows in the Northern Basin: responses of fish to changes in flow in the Northern Murray–Darling Basin – Valley Scale Report*. Final report prepared for the Murray–Darling Basin Authority. NSW Department of Primary Industries, Tamworth.

NSW Department of Primary Industries (2015). *Fish and Flows in the Northern Basin: responses of fish to changes in flow in the Northern Murray-Darling Basin – Reach Scale Report*. Final report prepared for the Murray-Darling Basin Authority. NSW Department of Primary Industries, Tamworth.

This review focusses on the reach scale report because that is where the EWR's are developed and presented. Sections quoted refer to that document unless otherwise stated.

1. These reports include a lot of summarised information on each of the major catchments of the Northern Murray Darling Basin but the information is largely not used because the EWR's are only developed for the Barwon Darling reach with no comment made regarding the tributary valleys.
2. Section 2.4 of report 2 notes with respect to selection of priority reaches: "The MDBA nominated a number of reaches that should be considered initially as potential priority reaches for the project, namely:

- Barwon River between Walgett and Brewarrina
- The Barwon and Darling Rivers between Brewarrina and Bourke
- The Darling Rivers between Bourke and Louth
- The Darling River between Louth and Wilcannia
- The Balonne River between Jack Taylor Weir and the junction of the Culgoa and Balonne Minor Rivers
- The Culgoa River
- The Narran, Birrie, Bokhara and Ballandool Rivers."

I have not reviewed earlier documents that may have given a reason for the focus on this one flow path at the exclusion of all NSW tributaries, Border Rivers or Condamine above St George. However given this initial focus, the broader literature review and any other comment on the other valleys appears peripheral to the purpose.

3. The aim of the first phase of the work, the literature review was "to determine the specified systems and river reaches where existing information is sufficient to deliver the project activities and outputs' with a specific emphasis on information to improve the understanding of key fish community responses to specific flows'. Only the Barwon-Darling below Walgett was judged to have sufficient information.

4. Part of the reason is that NSW DPI has a particular focus on detailed fisheries related habitat mapping and it was only available in this reach. As this was known at the start of the project it again seems odd that any time was spent on the other valleys.
5. As the reach in question; Walgett to Wilcannia, receives very little input (other than the Warrego), any water to satisfy flow requirements in the reach must come from the upstream tributaries.
6. Similarly the EWR's are proposed at three locations within the reach hence the water required to satisfy that specified at the more downstream locations (Louth or Wilcannia) must be sourced from above the most upstream location (Bourke). Using three locations may be intended to ensure that flow passing one point is not extracted before it reaches the next point however it could also result in unbalanced outcomes. For example the natural flow regime here sees a decrease as you progress downstream yet the low flow target at each point is set at the same level and the high flow target actually increases.
7. The habitat mapping by NSW DPI covered various habitat attributes but that related to snags and benches were the only inputs (from that mapping) used in the derivation of flow indicators. That is, what flow level is required to inundate X% of mapped snags or benches? "The availability of snags under different in-channel flow components did vary considerably between zones; however small in-channel pulse events (defined as meeting a 6,000 ML/day threshold) provided the greatest proportion of snag inundation for most zones, including 59% for FPZ3 (Walgett to Brewarrina) and 47% for FPZ4 (Brewarrina to Bourke)".
8. Despite the above, the basis of selecting 6000 ML/d as the threshold is unclear. Table 8 shows in-channel freshes as between a 15th and 30th percentile but there is no figure that relates to 6000. The figures in Table 8 also don't reconcile with the percentiles presented in Appendix A so it is assumed they were either drawn from a different modelling source or calculated different (e.g. annual percentiles rather than monthly). It is unfortunate that given the literature review component of the project the source of the data in Table 8 is "unpublished". This occurs several times in the documents.
9. The basic logic behind the link between habitat features and flow is that these features provide various benefits when wetted and they are wet less often now than in the pre-development scenario. The benefits associated with snags are listed as: woody habitat is a major ecological and structural element of waterways, providing hiding and resting places for fish out the main flow of the river, spawning sites and territorial markers for several native fish species, in developing scour pools and preventing erosion through bank stabilisation and as instream wood breaks down it also provides food for benthic algae, invertebrates and microorganisms that form a large part of the food web for fish species. There are strong associations between large wood and fish species such as Golden Perch and Murray Cod. More complex snags are important as they offer greater protection to aquatic fauna from predators and are more useful as breeding sites. Not mentioned is that wood is not only a food source for invertebrates etc but a substrate upon which they can live and to which algae can attach. Wood protruding above surface also provides for turtle basking or bird perching. This isn't new information; every recreational angler knows the importance of snags. The effect of snags on an otherwise largely featureless river bed is similar to the creation of artificial reefs by sinking former warships in relatively shallow nearshore environments and in both cases the success of the venture is maximised by actually having the structure or snag in the water rather than exposed.
10. There is a fundamental problem with the assumption that the way to increase the habitat benefits from snags is to raise the water level for short periods to reach them in their current

location. A superior result would be achieved by lowering the snags to the current water level and have them submerged more often.

11. This approach of using water level to solve a problem is also applied to fish barriers in the system wherein the 10,000 ML/d flow indicator at Bourke is specifically applied to drown out the Bourke Weir whereas fish passage could be achieved, and in all likelihood more frequently, more reliably and for more species, by fitting a well-designed fishway.
12. This is an issue I have raised many times over the years where managers seek to use a volume of water to solve issues which are either not essentially caused by volume or are better solved by other means, means which would cause less impact to rural communities and agricultural productivity. The response is usually along the lines of "that's being addressed by others, we are tasked with managing water flow and volume." However if it is being addressed by others then it should be excluded from needing to be addressed by the water managers. The issue with snags is lack of habitat, not lack of flow. The issue with weirs is blockage of passage, again not lack of flow.
13. Section 6.1.2 notes "The accepted benchmark for snag loading in the Barwon-Darling River was previously determined by NSW DPI to be 7.7 snags/km at low flows, defined as being inundated during greater than 90% of flows, and 46.83 snags/km within the channel (Boys, 2007; Boys *et al*. 2013)." Whether this "benchmark" is current or historical is unknown. While no specific comment was found, it is assumed that the number of snags is less than ideal and that an increase in access to snags will sustainably support larger fish populations. This would appear logical given comments about historic de-snagging and a focus on re-snagging in the various demonstration reaches.
14. The provided data show that only 14% of the total snags are actually inundated at low flows (90^{th} percentile) and this equates to only 1 snag every 130 m on average, suggesting there is ample capacity to increase the number of snags submerged or largely submerged at baseflows. Is there any reason to believe that such a strategy would not provide greater snag related net productivity in the aquatic environment and a better fish related result than using the 6000 ML/d flow to inundate otherwise dry snags for periods of just 8 – 20 days?
15. Murray Cod is the focus of the snag comments (though not exclusively). The importance of snags to Cod is clear from National Recovery Plan for Murray Cod (2010) which states "Murray Cod are usually found associated with complex structural cover such as large rocks, large snags and smaller structural woody habitat, undercut banks and over-hanging vegetation" and "During the day they normally seek shelter around logs and other woody structure, the resting places appearing to form the focal point of their territories" and "Murray Cod have generally been considered to be sedentary. This is largely so for autumn and winter when movements are localised and site fidelity high. Both lake and river fish have been shown to undertake substantial long-distance movements prior to spawning, returning to their original territory several weeks after spawning. Homing occurred for about two thirds of fish." Hence, the major benefit of snags to Cod is in being permanently inundated, not occasionally inundated for short periods.
16. Only if Murray Cod preferred newly inundated snag habitat for spawning could the proposed basis of the flow indicator be preferred. This is not the case, for example the Recovery Plan states "Reproduction appears largely dependent upon water temperature, with flooding or a rise in water level apparently not required to initiate spawning". Hence newly inundated substrate cannot be a requirement for successful spawning. (It should be noted that the classification of Murray Cod in the Final Report as "flow dependant" with regard to spawning (Table 2) is at odds with common understanding, including the Recovery Plan which states "Upstream movements may coincide with rising water levels, although some movement

occurs without flooding. Migration does not appear essential for spawning as Murray Cod are known to spawn in impoundments (Cadwallader and Gooley 1984) and farm dams.")

17. With respect to other benefits of snags not related directly to fish, a snag which is not permanently or substantially inundated offers little benefit. It can't develop a scour pool or offer a substrate to algae, sponges or macroinvertebrates hence be a food source for fish, nor can it offer preferred basking or perching habitat to turtles or birds.
18. The final report states with respect to the flow indicators at Bourke; "The main outcome for the 6,000 ML/day event is regular habitat access and movement opportunities, and it is therefore considered appropriate for the event to occur any time in the year." The relevance of habitat access related to snags is discussed above. With respect to movement opportunities, no evidence has been presented of the relationship of any flow level (other than weir drown-out) to movement opportunity. There is no mention of natural barriers and in low gradient systems such as this, even baseflows can allow largely unrestricted movement between man-made barriers such as weirs or causeways. Baseflows in this system are currently well above the natural levels (Appendix A).
19. It also states "The minimum duration of 14 days is linked to the natural hydrology and the hatch time for Murray Cod eggs." So while the event is not sized for Cod spawning, the duration is. It is difficult to find any information confirming the link to natural hydrology. Table 10 presents durations only within specific flow windows but that shows the first window above 6000 ML/d has a mean event duration of 6.7 days. Table 13 presents the percentage of years within which a flow indicator occurs and if it is referring to the event (at least that flow level for at least that duration) then 14 days of flow above 6000 ML/d is a common event (occurs in 96% of years).
20. Appendix A Without development flows at Bourke, shows that in likely Murray Cod spawning months of October and November, a snag which required a 6000 ML/d flow to inundate it, would be dry for over 70% of the time.
21. Murray Cod has a spawning period covering a few months so the 14 day duration is only relevant within that period. At Wilcannia the duration of the 6000 ML/d flow has not been linked to Cod spawning and is only 8 days. As such, outside the Cod spawning period at Bourke, why is any longer than 8 days required?
22. In line with Point 7, it appears a flow level of 6000 ML/d was used at all three gauging stations despite the natural flow varying considerably between the locations (Table 8 .
23. At Louth the 6000 ML/d pulse (and the higher flow) is set with a duration of 20 days and "is based on known spawning and recruitment requirements for In-channel Specialists, where a stable flow peak for up to 20 days allows for nest establishment, maintenance, and egg hatching". 20 days is also used for the 10,000 ML/d flow at Bourke on the same basis. The 14 day requirement at Bourke for the 6000 ML/d flow appears not actually related to successful Cod larval dispersal.
24. The 6000 ML/d flow at Wilcannia is not related to Cod or fish breeding but to bench inundation and an apparent link to productivity increases through nutrient release; "The shorter durations of the two proposed flow indicators is considered adequate to enable the release of nutrients, with the majority of releases largely occurring in the first 24 hours of inundation before stabilising." If the focus is on benches then a flow of 2500 ML/d would inundate about 80% of benches and this target is normally more than acceptable. Similarly the reports notes that a flow of 6000 ML/d would drown out the weir at Tilpa. The weir would be drowned out at 2400 ML/d so there appears no reason to use 6000 ML/d.
25. "Benches are identified as areas of relatively flat sections within the main channel that play an important function in the aquatic environment by enhancing the diversity of habitat and

contributing to productivity processes. They are an actively accreting fine-grained, bank attached feature within the river channel that influence flow and provide variation in water depth (Vietz *et al*. in press). Benches also store carbon, releasing it for sequestration to other parts of the aquatic ecosystem when inundation occurs, playing an important role in primary production and condition aspects for aquatic biota." The question is, how important are these processes and benches?

26. The mapping of benches covered 1100 km of river (or 2200 km of bank) and found 745 benches totalling 111 ha in area (outside weir pools). That is one bench on average per 677 m of river (or 1344 m of river bank) and with an area of just 0.15 ha. Using a very conservative river width as per section 4.2.1 of the Valley report, the benches represent about 0.02% of the river bed area in the reach. That area could not possibly make any more than an infinitesimally small contribution to the total carbon and nutrient input to the reach from all sources. This should not a basis for flow related management.
27. The assumed importance of benches is related to their release of nutrients; the general consensus is that the nutrient load in our rivers is of concern so this is similar to the issue raised in the reports about providing repeated large floods, because Carp will benefit as a result. That is, not all additional flow results in positive impacts.
28. With respect to habitat, again the benches represent a very small area. The same argument applies to this habitat as it does to snags, that is, making habitat available for small periods of time is of minimal benefit. As benches are not a structurally diverse habitat (unless vegetated or containing snags) they offer much less than snags. This is not to say that benches don't have value, but the difference between using 6000 ML/d or 2500ML/d at Wilcannia for a 20 day flow equates to about $30,000,000 in cotton crop (per year) so when ecologists put forward criteria they need to be more than an item of whimsy.
29. The larger flow at Bourke (10,000 ML/d) is noted as linked to the drown-out requirement of Bourke Weir, but as noted, that is not a reasonable use of the water resource. All of the various connectivity and movement benefits noted by the authors could be achieve by a well designed fish passage device. No weirs require drown-out between Walgett and Bourke because Brewarrina Weir now has a fish passage device. Priority should be given to fish passage devices on weirs 19A and 21 as they isolate relatively short sections of river from longer sections. Using large flow volumes in this manner takes water out of productive agricultural use <u>forever</u> whereas spending capital on provision of fish passage is one-off plus minor maintenance costs if built correctly.
30. As noted the duration of the higher flow or large pulse at Louth (21,000 ML/d for 20 days) is based on spawning and recruitment requirements of in-channel specialists. Table 2 lists the in-channel specialists and describes their attributes and implications for flow management. The guild contains two sub-groups, one is noted as flow independent. Flow-independent is self-explanatory so those species are not relevant to the discussion (unless the authors have made a serious error in titling). The other group are "flow dependent" and it has only two members, Murray Cod and Trout Cod. Murray Cod has been discussed above and does not rely upon any particular level of flow for spawning or recruitment though the latter may be enhanced by <u>a level</u> of flow. Trout cod is a species of montane and slope zones and is not present in this reach with the nearest historic record being from the Macquarie River. Hence, what is the actual link to a need for a large pulse?
31. Similarly why is 21,000 ML/d the chosen flow level when Louth and Bourke have very similar flow regimes yet the peak at Bourke was 15,000 ML and then only for 5 days. I found no justification for this short peak within a peak.

32. In Table 2 when describing the flow requirements of flow dependent specialists, it is sometimes stated that a flow pulse is required but when a level of such pulse is mentioned it is only a small pulse; “research in the Northern Basin suggesting that the first post-winter flow pulse may be important for pre-spawning condition and migration in some northern systems (Marshall, et al. in press),” “Flow events do not have to be large pulses, with small, sharp rises in flow also providing benefits and eliciting responses from species (Marshall et al. in press).” There is no mention of a requirement for a large pulse for this guild or any other guild of in-channel species for any stage of their reproductive cycle. For the generalists, the only mention of a level of flow relates to “low to moderate flow events.” High flows are required for the floodplain specialists but they are not the subject of this report.
33. However, Figure 4, which “identifies different flow requirements that would benefit each functional group” in the form of ideal expert panel generated hydrographs related to spawning and recruitment includes a large pulse as required for both Group A (flow dependant specialists) and Group B (in-channel flow dependent species). I did not find any text which supported such requirement and there is strong literature evidence of successful breeding and recruitment of these species without large pulses.
34. Section 2.2 states “The flow regime of the Northern Basin is one of the most variable in the world, playing a vital role in the ecology of the aquatic and riparian environment of the system (MDBA, 2012). The variability of flows across the Basin has helped create habitat diversity and availability in the system”. This is also why Australian aquatic communities including fish have developed life history strategies which are commonly regarded as highly flexible, making the species both tolerant and resilient. In the case of fish this is probably why they move and / or breed in response to relatively small flows as to miss the opportunity in favour of waiting for a larger flood would be a risky evolutionary strategy.
35. This is not to say that fish do not benefit from occasional larger pulses, primarily related to the connection to flood runners and other offstream areas but this document was deliberately restricted to in-channel processes which in themselves do not justify use of such larger pulses as flow indicators. The habitat mapping exercise apparently included commence-to-flow of flood runners and offstream waterbodies but it has not been used as justification for the specification of the larger pulses.
36. Table 13 lists the 7 site specific flow indicators. The associated text notes “the frequency targets are expressed as a range and have been developed with reference to how often the desired flow events occurred under without development conditions. In some instances where ecological knowledge is less certain to define a frequency target, a range of 60 – 80% of the without development conditions frequency was used as a guide to establish targets. This approach is consistent with the approach applied by the MDBA for the original EWRs for the Barwon-Darling river system where low and high uncertainty frequency targets were set to recognise the degree of confidence in specifying a desirable frequency (MDBA, 2012a). The rationale for using 60 – 80% of without development frequency as a target frequency range is also documented within the Barwon-Darling EWR report (MDBA, 2012a).” (The literature review document notes “Detailed eco-hydrological assessments undertaken by MDBA explicitly excluded 'regions where current end of system flows are above 80% of without development flows' (Paroo, Ovens, Eastern Mount Lofty Ranges and Warrego) (Murray-Darling Basin Authority, 2011; p.35). The Moonie was also excluded as 'it has the lowest contribution to the Basin’s water availability and close to 80% of its natural flow' (Murray-Darling Basin Authority, 2011; p.36).” Similarly the MDBA has historically used 67% as a rule of thumb for assuming a high probability of maintaining a healthy working river.

However the targets in Table 13 do not appear to relate well to this discussion and have sometimes been set very conservatively.

In the table below, Baseline refers to the current modelled water resource development in the Northern Basin, I assume under full utilisation. It represents greater water use than the existing recovery scenario which would likely show improved results (it certainly did in the waterbirds documents). Also, the term High uncertainty is a somewhat evocative and potentially influential term which could possibly be replaced by “higher uncertainty.”

Location	**Flow threshold (ML/d)**	**Low uncertainty frequency target (% of without development)**	**High uncertainty frequency target (% of without development)**	**Baseline frequency achieved (% of without development)**
Bourke	6000	83	83	71
Bourke	10000	90	67	62
Bourke	10000-15000	80	60	48
Louth	6000	77	77	66
Louth	21000	74	74	59
Wilcannia	6000	80	60	53
Wilcannia	20000	80	60	55

Only three of the flow targets match the 80-60 criteria while for all others the higher uncertainty target is substantially higher than 60%. In three cases the high and low uncertainty are the same and at least 74% of without-development, indicating a very conservative setting. Two of the low uncertainties are set above 80% with one set at 90%.

However even under Baseline levels of water resource development, 3-4 of the 7 indicators would already meet a 60% high uncertainty target (highlighted green or yellow). Under current recovery (not shown) two of the others (Wilcannia) may also meet that target. Similarly if the small pulse flow at Wilcannia was adjusted as suggested above (from 6000 to 2500 ML/d), it would likely be satisfied by existing conditions.

Setting low uncertainty targets at or near 80% is reasonable for flow indicators that are an essential requirement, such as small pulses (when a suitable pulse threshold is developed) but not for larger in-channel pulse thresholds which provide only incremental improvement for a proportionally much larger water investment. For example the small pulse total volume at Bourke is 84,000 ML while the largest pulse requires a commitment of 450,000 ML (including the multiple events dictated by the timing). Will provision of the large pulse produce a 5.36x better result than the small pulse? At Louth the ratio is 3.5.

37. This leads back to the issue of a more holistic approach to fish community management where flow is just one part of the overall approach. The report states “The outcomes achieved from water recovery and management in the Northern Basin would be greatly enhanced by the development and implementation of a complementary aquatic habitat rehabilitation and adaptive monitoring program.” The various other factors mentioned in the reports include; fish passage, degradation of in-stream habitat and riparian vegetation, poor land management, water quality, temperature (e.g. cold water pollution impacts) and alien

fish species Clearly these other actions can also be treated as alternatives because they are useful in their own right. If they weren't then there would be little point in the time spent on the various demonstration reaches lauded in the reports.

38. Section 3.2 also states with respect to these factors "are largely outside the scope for this project but consideration needs to be given to them during the development of water management actions." As noted earlier the EWR and SLT are being developed without any consideration of these other factors because the Water Act only addresses water and flow. But somebody has to do it otherwise there is absolutely no doubt that the outcome will not be balanced or the least socially impacted because water is the most valuable commodity to society and rural communities in particular.
39. In various previous commentaries I have suggested that these other issues should be addressed <u>first</u> because addressing habitat will have no impact on rural productivity and addressing connectivity via removing redundant weirs or fitting fish transfer devices would likely have a small impact but is more a "all of society" cost.
40. Often the key limiting factor is not flow but some other non-flow related factor. In looking at fish guilds it was noted (Section 3) "the eco-hydraulic recruitment guild approach" focussed on hydrodynamics and flow but "water temperature and water quality information was not considered in this method as it was believed these factors would dominate the life history characteristics considered in the approach, and as a result there is potential that these guilds would not be applicable in rivers impacted by reduced water temperature or water quality (Mallen-Cooper and Zampatti, 2015)." In other words those river reaches affected by cold water pollution would not benefit from flow management and this has been clearly stated previously. For example the Regional Evaluation Group for the Mitta Mitta River between Dartmouth and Hume (MDBC Oct 2003) stated "full remediation of thermal pollution at Dartmouth dam would provide a 0.10 increase in Native Fish Habitat Condition index score towards the natural condition, which is a greater improvement than <u>any of the flow scenarios alone</u> would provide" (underline added). Equally clearly, thermal mitigation should be prioritised over any flow mitigation.
41. Also some of the goals of the BWS are best managed at a site basis or short reach basis and the key aspects of management may not be flow e.g. for olive perchlet or purple spotted gudgeon it will be maintenance of key habitat requirements such as macrophytes or shallow cobble riffle.
42. "Since the establishment of the Brewarrina to Bourke demonstration reach a significant amount of on-ground work has been completed along the reach, including the installation of over 400 pieces of large woody debris; over 8,500 native trees planted; over 100km of weed management undertaken; erosion controlled at three priority sites, and; nine off-stream watering points installed (NSW DPI, 2011).
43. With respect to the literature review component of the project it is certainly useful to regularly update information and to categorise it according to its utility. The Smartrivers monitoring reports are listed but incorrectly attributed to Ecological Management. The attribution should either be EM (Ecology Management) Pty Ltd or Smartrivers.
44. The EM report of spring 2011 was apparently not reviewed which is unfortunate because it was a post-flood report and was the only sampling event jointly conducted and funded by Smartrivers and Government.
45. The 2011 report also reported a boom in carp numbers after successive years of flooding and this agrees with comments made in the documents regarding a risk of re-establishing significant repeated floodplain flows.

46. Appendix 1 is the actual log of literature with a short description of the basis of the report and a ranking according to the BASK approach. The report states "While acknowledging weaknesses of this approach (for example, Environmental Evidence Australia 2010; p.14), it is still considered a suitable starting point", however, it does not state what those weaknesses are.
47. The ranking relies heavily on "Sheldon et al (2014). Reviewing the scientific basis of environmental water requirements in the Condamine-Balonne and Barwon-Darling: Technical Report June 2014. Murray-Darling Basin Authority, Canberra". The log quotes Sheldon et al as stating with respect to the EM reports "Does not 'provide a context for ecological response to wetting or drying events' yet this statement was also made with respect to the Sustainable Rivers Audit but it is not quoted with respect to that report.
48. The EM reports commenced before the drought, carried on through the drought and including sampling after the drought. They reported fish species recruitment in various habitats across a range of flows so while their primary purpose or initial context was not specifically related to ecological responses to wetting or drying events, they contain useful information to investigate such issues.
49. Technical reports supporting the WAMP (DNRM 2000) are given the same BASK ranking as the EM reports yet these were the documents which were essentially discredited by the Cullen Review.
50. The review states "Given the absence of baseline information on fish community or ecosystem health, non-scientific information can also provide useful supplementary information" – as such and given that the EM reports for Smartrivers were baseline information, that they should be seen as of more use than all the models and the papers reporting nothing more than conjecture but which did not generate any actual data.
51. Section 4.5 (conceptual models) of the literature review states: "the Murray Flow Assessment Tool (MFAT) used functional groupings for fish and other water-dependent taxa. Available literature and expert opinion were used to derive response curves for relevant flow-related habitat conditions, such as flow and spawning timing and flow duration (Lester *et al*, 2011; p.2459). However, MFAT has had limited success in predicting responses of real-life fish assemblages or functional groups (Lester *et al*, 2011; p.2463)." EM (Benson 2004) reviewed this model on behalf of Murray Irrigation and reported "MFAT primarily models flow related habitat, hence is very limited in its real world application, where many more variables actually exist" and "The outputs of MFAT cannot be validated in the real world so it has little application to target setting or adaptive management". The clear disjunction between conceptual models, no matter how well intentioned or funded is not new.
52. The literature review is written in future tense, which is very odd and is not complimentary of the input from Queensland agencies ""Access to information in Queensland MDB catchments may be more challenging". In other documents there is no clarification as to whether information was eventually forthcoming from Queensland.
53. The overall project relied heavily on the expert panel approach, such as for the establishment of eco-hydraulic guilds and conceptual flow models, and as the Valley report acknowledges in Section 3.2 "As with any approach that draws upon expert judgement, this approach does have some possible limitations, including the potential for bias, poor calibration or to be self-serving".
54. Section 2.3 of the Valley report notes "The results from the Fish Community Status project mostly align with those of the second Sustainable Rivers Audit (SRA) report, which found that the fish community of the majority of valleys in the Northern Basin are in an extremely poor

to poor condition, with only the Border Rivers (moderate), Condamine (moderate) and Paroo (good) being in a reasonable condition (Davies *et al*. 2012). The second audit largely repeated the first in which of the 23 rivers in the basin, the Queensland rivers ranked 1 (Paroo), equal 2nd (Condamine and Border rivers) equal 3rd (Warrego, along with Namoi and Ovens). The Lowland section of the Condamine has also independently ranked relatively highly for ecosystem health compared to the NSW valleys of the basin, suggesting there are fundamental differences in how development and water management operate (primarily water harvesting V major headwater storages and strong regulation).

55. Given that the focus of the fish reports is the Barwon Darling and all of the NSW rivers draining into it rank poorly for ecosystem health compared to the Queensland valleys, it should be clear where the focus for management should be.

National Murray Cod Recovery Team 2010. National Recovery Plan for the Murray Cod *Maccullochella peelii peelii*. Department of Sustainability and Environment, Melbourne.

Benson, L., (2004) The Science Behind the Living Murray Initiative – Part 2
Murray Irrigation Limited, Deniliquin NSW.

MDBC (October 2003) Ecological Assessment of Environmental Flow Reference Points for the River Murray System (Scientific Reference Panel for the MDBC).

ATTACHMENT C

Review of Waterhole refuge mapping and persistence analysis in the Lower Balonne and Barwon–Darling rivers

DSITI (2015). Waterhole refuge mapping and persistence analysis in the Lower Balonne and Barwon–Darling rivers. Department of Science, Information Technology and Innovation.

This project addressed knowledge gaps about the location and persistence of waterholes in the Lower Balonne and the Barwon–Darling, with detailed field work and modelling done for a subset of over thirty waterholes along the Culgoa, Narran and Barwon–Darling rivers. The research questions addressed were:

- Where are persistent and refuge waterholes across the Lower Balonne and Barwon–Darling regions?
- How long do waterholes persist in this region?
- Does groundwater impact the persistence time of waterholes?
- Does sedimentation affect waterhole persistence?
- Can the persistence time of waterholes across the northern Basin be predicted using a generic model?
- Do hydrological modelling scenarios show an impact from water resources development and a benefit from the recovery of environmental water to the persistence of waterholes (modelling period between 1895–2009 for a range of different management conditions, including without development, 2009 pre-Basin Plan baseline conditions of development, and hypothetical recovery scenarios)?

Review

- The current EWR is “A flow indicator of 1,200ML/day for seven days at Brenda gauging station on the Culgoa River, with a maximum interval of between 22 and 28 months (1.8 to 2.3 years) was developed to represent the watering requirements of waterholes (MDBA 2012).”
- The key outcome of this project with respect to Environmental Water Requirements is “In conclusion, the minimum risk threshold determined at both the reach and individual waterhole scale in this project does not exceed one and half years of no flow. This shows that the existing EWR used by the MDBA (22 months) was an overestimate and was inadequate for the maintenance of refugial waterholes across the Lower Balonne.” That is, the interval should be reduced to 18 months.
- Another recommendation was “Review flow requirements needed to fill waterholes along the Culgoa and Narran river valleys. If required, update the 1,200 ML/day for seven days site-specific flow indicator.” This means the volume and duration of the low flow could potentially change, though no specific recommendation was made.
- The assessment included waterhole features within river channels (divided into 17 reaches) that are maintained primarily by in-channel flows and retain water during dry spells.

Floodplain features, relicts no longer connected to the active channel, and off-stream storages were excluded." That is, only main river channels were assessed so significant offstream or floodplain waterbodies were not included.

- There is no mention of consultation with landholders.
- The report assessed waterhole persistence in two ways: landsat images during no-flow periods, and modelled waterhole persistence using an eWater model.
- For the first approach the report used actual flow gauge data to find extended periods of no flow (<2ML/d).
- They then reviewed Landsat images collected between 1988 and 2015 to detect waterholes which persisted during those periods of no flow. The period included some periods of significant low flow such as around 1991, 2001 and the millennium drought.
- The report noted the problem of actually recognising water and applied various means to overcome it. "The default water index threshold was originally optimised for large, open waterbodies such as oceans and lakes. This default water mask was evaluated for its sensitivity in detecting waterholes in the northern basin by comparing the water extent it produced with the extent of in-stream riverine water bodies within the Landsat image. This default water mask was found to significantly underestimate the presence of water in rivers in the region. Subsequently the default threshold was modified in order to optimise surface water extent identification in inland rivers, including water under sparse vegetation, water across a range of water quality conditions and in small, narrow river reaches, to ensure instream waterholes were identified." Similar issues have been raised previously with interpreting floodplain inundation and it is certainly an issue of considerable concern.
- The nearest downstream gauge defined a reach and a waterhole could be anywhere within that reach, meaning it may be upstream or downstream of a major water extraction point. The period in question also saw considerable change in the extent of water extraction so how did they take these factors into account when examining specific waterholes? The results simply express what actually happened so certainly include an extent of extraction on that drying time.
- Some of the description of mapping layers is confusing, particularly the purpose of including a minimum of 4 pixels (3600m^2) in the maximum waterhole extent layer. Does this mean small (but possibly deep) waterholes are not included? A single pixel is 30x30m.
- The review concluded "Analysis showed that in all assessment reaches, waterholes retained a small amount of wetted habitat during the longest gauged no flow spells within the Landsat time-series". "Small" is a subjective term but the data is provided.
- Table 2.4 shows 191 ha of wetted habitat in the Weilmoringle reach after a no-flow spell of 604 days, 154 ha after 595 days at Brenda and 181 ha after 593 days at New Angledool. Given the latter assessment of reach "stress" proposed level 1 as 350 days, level 2 as 548 days and level 3 (all water gone) at 720 days, this result appears to suggest those levels are potentially harsh. This outcome is real data reflecting the level of extraction and other characteristics at the time, that is, it is not modelled data.
- This section also states "The spell length that equates to zero wetted habitat was estimated by extrapolating the relationship between wetted habitat and spell length. The projected maximum persistence time was longer than the longest measured spell." What this means is that waterholes would persist past the longest measured no-flow spell. However the authors chose not to use this estimate on the basis of scatter amongst the data points.
- The data in Table 2.4 seems to conflict with that in Table 2.3 which suggests much smaller areas of vestigial water remained within a low number of specific waterholes. "Only 37 hectares of wetted surface area was available after spells longer than 350 days across all four

reaches and the largest area was mapped in the lower reaches of the Narran (Table 2.3). Of the 37 hectares of wetted surface area mapped across the Lower Balonne, ten refugial waterholes were identified and eight of these waterholes were within the mid to lower reaches of the Narran River valley (Figure 2.3)".

- Appendix B provides maps of all the waterholes and if one hovers the cursor over the map, descriptive text is provided. Depth is never mentioned as they have no way of estimating it from landsat images.
- The second approach to assessing waterhole persistence was via using a model developed in the Moonie River. They collected field data to adjust and calibrate the model and this data included in the rate of drying of waterholes (using depth sensors), waterhole bathymetry (using sonar) and groundwater inputs (using various geochemical tracers). Some 30 waterholes were included and sampling took place from mid-2014 to early 2015. While intended to be a mix of natural and man-made waterholes, the list includes few weirs (sometimes it includes parts of weir pools). Section 3.2 (modelling water hole persistence) notes (underline added) "Many waterholes in the region have been made artificially deeper with the installation of weirs and rock walls at the downstream end; in some instances these walls may be as high as two metres. As the deepest pool used on the Culgoa was at Weilmoringle at 2.97 m, the deepest on the Narran was Angledool at 3.06 m (Clyde was 1.87 m and Booligar was 2.57 m), it does not appear that the deepest man-made pools have been included. This indicates that some of the real refuge pools in the region have not been identified.
- Calibration was not always possible because the period in which drying data was collected was not long enough.
- One of the key parameters estimated is minimum persistence time; "the shortest time in which the waterhole can dry from completely full at cease to flow. This was done quite simply by reducing all gains to the model waterhole to zero." That is, no flow and no rainfall. They present data on actual gauged no-flow periods to get an understanding of the reality of that component but no data is the presented on the "no rainfall" assumption. How real is it? Lowest rainfall year at Beardmore (longest period of record in the area) was 304 mm. As direct rainfall on a waterhole (so assuming no associated catchment runoff) this would make a roughly 50 day extension to the predicted duration using their derived formula (Section 5.3.1 notes "Persistence (days) = Depth (metres) x 168.91).
- "Overall, persistence time is well estimated by the water depth". Table 3.6 is estimated persistence time (days) with no inputs. The results do not support that the suggested simple relationship with maximum depth is a good predictor of persistence. This shows that Inge dried at 1.5x the rate (cm/d) at which Westmunda dried. In the Narran the variation was greater, with Golden Plains drying at nearly twice the rate of Amaroo. This also results in the wide confidence intervals noted below.
- Section 5.3 notes "There is, not surprisingly, less confidence in predicting persistence time for new maximum depth observations (Figure 5.3, dashed lines), where the standard error is 121 days." It later states; "Lastly, the 95% prediction interval appears to be quite large (±121 days), but if the data are normally distributed, the predictions will be on average much closer to the centre of that range (i.e. what the model predicts). A 95% confidence interval provides the range in which 95% of values are expected to fall, that is, throughout that range the model should only be wrong in 5% of predictions." In other words they could be 95% confident that the answer is somewhere within a range of 242 days. These confidence intervals ARE large relative to the levels of change the authors are recommending. Given that

the current EWR period is 22 months and the authors of this report recommend reducing it to 18, that's a change of only 120 days.

- Section 3.4.1.2 states "In the Culgoa and Narran rivers, approximately half the modelled waterholes would go dry after one year without input. After two years without input none modelled waterholes would still contain water (Figure 3.12 & Figure 3.13). This means that in order to retain a proportion of the waterholes permanently, there needs to at least be refilling events at least approximately every 18 months." This is not an appropriate statement at this stage of the report. There hasn't been any comparison with the without development situation undertaken so if drying is natural, then drying should be preferred in a balanced scenario.
- "If the waterholes are to act as refuges, then input events must be at a frequency that tops up the waterholes before they become dry. In order to retain 50 centimetres of water depth the maximum duration with no inputs is approximately 550 days, which leaves only one of the modelled waterholes in the Narran River (Angledool), and none in the Culgoa River." The idea of leaving 50 centimetres in the bottom is not debated.
- "Given that maximum no flow spells recorded at gauging stations in the Culgoa and Narran exceed these persistence times (Chapter 2) these waterholes are not permanent and are potentially at risk from water resource development." There is nothing wrong with this logic as long as the initial estimate of which waterholes last the longest and how long they last is accurate. As noted however, the landsat analysis suggests there is more water remaining after long periods of no-flow than the model outputs.
- The authors then compared modelled waterhole persistence across water resource development scenarios and concluded "While there is no evidence that complete region wide loss of waterholes is likely to occur in the Lower Balonne under the baseline conditions, the results show water resource development poses a significant risk to the function of waterhole as refugia in the region." The actual risk actually is addressed below.
- The results showed that "No flow spells in the Lower Balonne ranged from 292 to 682 days, with prolonged periods of no flow recorded in the lower reaches of the Narran and mid reaches of the Culgoa river valleys." Those particular reaches are between Woolerbilla and Weilmoringle on the Culgoa and downstream from the gauge on the Dirranbandi-Hebel Road on the Narran. More upstream sections did not have significant lengths of no flow periods and this allowed waterholes to naturally persist. The same was true of the lower Culgoa (below Nebine junction) and the Barwon Darling (which has naturally deep water holes).
- Table 6.4 shows the modelled maximum no-flow spell duration and frequency of no-flow events at various gauge locations in the Lower Balonne (and across the various water recovery scenarios). For the Culgoa it shows that the number of dry spells is only sometimes greater with water extraction but the maximum duration is substantially longer but for the Narran it shows essentially no difference in the maximum duration between WOD and Baseline at Dirranbandi Hebel Rd and less difference between the two (relative to Culgoa) at downstream gauges. For example New Angledool is 21% worse while Wilby Wilby is 17.7% worse. These are not reflective of significant levels of change.
- Table 5.4 also shows is that the volume of water recovered makes little if any difference to waterhole persistence. What this suggests is that the volume is not the relevant factor but how low level pulses can be appropriately provided when needed. The water extraction rules as they apply to low flows is what is relevant and these affect delivery irrespective of the total volume recovered.
- This is supported in Section 6.4.2 which states (underline added) "Our results also highlight that they (the various water recovery scenarios) have little or no impact on restoring the

durations of long spells without flow (Figure 6.2). Therefore, it is recommended that alternate recovery scenarios (including the potential to explore management actions) should be considered to mitigate risks to the refuge function of waterholes." The underlined is a sensible recommendation.

- Table 6.5 shows that two of the 4 tested waterholes on the Culgoa would only require management 6 times in the 114 year modelled period (once every 19 years on average) to bring them back into line (from Baseline) with the without development scenario. Noting that matching WOD is not normally the target, the average extends even further.
- For the Narran, management intervention might be required up to 15 times under Baseline scenario conditions (again this is to match WOD).
- The volumes involved are relatively small. For example the current EWR requires 1200 ML/d for 7 days or a total of 8400 ML.
- Privately owned offstream storages are often substantially deeper than natural river pools in the Lower Balonne so can store water for longer. It may be possible to hold water in such storages at the upper end of the reaches of concern and release low flows prior to key waterholes reaching their Threshold Of Concern. The intention of management would not to fill the waterholes but to stop them drying out, because even raising their depth by 0.5 m gives another 84 days of persistence. This would be a relatively low volume used only occasionally. Of course depending on where the water was released, the more upstream waterholes would fill and the river would flow till it reached the most downstream waterhole.
- This particular issue is one which clearly requires real time adaptive management rather than any change to the targeted volume of water recovered.

__**ATTACHMENT D**__

Review of the science behind the waterbird breeding indicator for the Narran Lakes.

Review of Merritt, W., Spencer, J., Brandis, K., Bino, G., Harding, P., Thomas, R., and Fu, B. (2016). *Review of the science behind the waterbird breeding indicator for the Narran Lakes.* Final report to the Murray-Darling Basin Authority. February 2016.

And

Brandis, K., and Bino, G. (2015). *A review of the relationships between flow and waterbird ecology in the Condamine-Balonne and Barwon-Darling River Systems*. Report to the Murray-Darling Basin Authority. Centre for Ecosystem Science, University of New South Wales.

The reports use the same data and modelling and it is difficult to tell which group did the primary analysis.

In this review Straw necked Ibis is abbreviated to SNI.

Key points

Merritt et al.

1. The definition of an event, meaning a hydrologic event within which a breeding event may or may not occur, is critical in that various parameters associated with the event are then used to make other predictions or conclusions. An event is defined as “The model with the best fit defined a flow event as starting an event when flow volumes were over 100ML/day at Wilby Wilby gauge on the Narran River and continued until water levels (mAHD) at Back Lake gauge were below 120.4mAHD”. The start threshold is a flow rate at a river gauge while the end threshold is standing water level at a specific point within the reserve. An “event” is therefore not a period of flow per se despite the authors (particularly Brandis and Boni) often referring to it as “a flow event”. It is a period of flow of variable length and a period of standing water which may also vary considerably.
2. The start threshold is apparently based on the opinion of Mr Peter Terrill; “A 100 ML/day threshold at Wilby Wilby was thought to be minimum flow required to reach the Narran Lakes (P. Terrill *pers. comm.* August 2015)” (Merritt et al). It is surprising that given the existing IQQM model, digital terrain model of the reserve and gauges within the reserve, that a scientifically based threshold could not be determined.
3. This start threshold is too low a flow and will result in a variable number of days of low flow being included within the volume and duration of “an event” when they clearly have little relationship to commencement of flooding or a breeding event. For example Figure 17 (Brandis and Boni) is the relationship between cumulative flows in the first 10 days and the first 90 days of an event. Any linear relationship on this figure is extremely weak. (R^2 just 0.17). What the figure does show is that there are a lot of relatively small events that never progress to be large events and never lead to breeding. Further, the secondary threshold flow used in the Narran DSS is 18,000 ML in the first 10 days or an average of 1,800 ML per day, well above the 100 ML/d figure.
4. The definition of the end of an event leads to extended event durations which are not related to SNI breeding. Standing water levels above the Back Lake threshold can be maintained for periods of months after flow at Wilby Wilby has ceased and after SNI chicks

have fledged. Figure 19 of Brandis and Boni shows event 29, the 2008 event. It is classified as commencing 22 December 2007 and ending 16 June 2008 (Appendix 6 of Merritt et al) for a duration of 178 days. Flow at the gauge started on 22 December and ceased about 12 March. Flow per se therefore lasted for about 81 days. There are two clear significant flood peaks and two clear SNI breeding colonies, one establishing after each of the peaks. Colony 1 established from 16 January and the chicks fledged by about 9 March so a breeding period of about 53 days. The duration of event associated with colony 2 is clearer: approx. 3 Feb to 30 March or about 58 days. Even if both colonies are combined into a breeding period, from flow commencement to fledging from Colony 2 is a period of 100 days. The period after fledging is irrelevant to any association between hydrology and waterbird breeding events. While the authors discuss inclusion of a period of post-fledging parental care, there is no little information which indicates reliance of such a period on water levels so it is not included in any of the models.

5. Section 3.3.3 of Merritt et al noted ""Given the opportunity for multiple breeding events across extended wet periods as observed in 1983-85 and 2010-11, splitting large events into two or more flow events is more useful for water planning at event scales." This statement is absolutely correct and also relates to the issue of over-stating event volumes and durations. The authors upgraded the Narran DSS to an extent to minimise the problem, but only to an extent. Unfortunately there is no single table which allocates breeding event to their respective flow event window. From the various appendices it appears that hydrologic events which contain multiple breeding events still occur in event 15 (colonies surveyed in July and November 1983 and May 1984; the event went from May 1983 to February 1985), event 18 (surveys in April and September 1988), event 24 (surveys in March and July 1997) and event 31 (surveys in November 2010 and February 2011). Similarly there are breeding events which contain more than one survey and the time between the surveys could indicate more than one breeding event e.g. 1983 as above and 1976 (surveys in March and July). Also as discussed above event 29 (2008) is classified as a single breeding event despite having two clearly distinct colonies and starting flow peaks. Quite clearly the stimulus to commence breeding in the first episode within such hydrologic events is often extremely unlikely to be the same stimulus for the second breeding episode so in these cases, the stimulus is not being correctly identified.
6. Thirty three hydrologic events were identified in the period which overlaps with the records of SNI breeding at Narran Lakes. Eighteen of these events overlapped with a SNI breeding event (meaning 15 did not) so the hydrologic event itself is little better than a coin toss in predicting whether breeding events will occur or not. It also clearly over-estimates the likelihood of a breeding event.
7. Section 3.3.5 of Merritt et al states "It is important to recognise that the Straw-necked Ibis model in the Narran DSS makes one prediction of breeding initiation, total nest numbers and nest abandonment for each defined flow event. It does not predict when, during the event, breeding will be initiated (rather whether hydrological conditions should support breeding initiation at some stage during the event)". The latter is a very important point.
8. Survey dates did not coincide with commencement of breeding but Merritt et al did attempt to predict the start date of every breeding event (Section 3.2.3). Unfortunately it doesn't appear that this was used in relating breeding initiation to flow statistics.
9. The approach to investigation of triggers for the initiation of breeding could have commenced by focussing on the breeding rather than a guestimate of what constitutes suitable hydrology then analysing how that related to breeding. For example once the date of initiation of breeding was estimated (as per section 3.2.3) investigation of the preceding

flows and water depths could have focussed on just those breeding events, rather than identifying hydrologic events which were clearly not a trigger to initiate breeding. Once potential triggers were identified it would be important to review non-breeding years in which the hydrologic triggers were met and ask "why didn't breeding occur at this time?"

10. Brandis and Boni report using another variation of this approach "For breeding records originating from other sources, we matched the survey month with total cumulative flows during that month and the previous two months (total of three months)." Again this is not ideal because the position of the survey within the 66-94 day breeding / nesting period is not known (viz, start, middle, end?).
11. Section 3.3.4 of Merritt et al notes with reference to the DSS "Where flow events do not meet either of these flow thresholds at the start of the event, the whole flow event is checked to identify whether these thresholds are met at any point during the flow event. If so, the likelihood of breeding initiation is updated". No information is provided as to how often this occurred, however it appears to be saying that the "flow in the <u>first</u> 10 days or 90 days threshold" is actually the flow "in <u>any</u> 10 day or 90 day period" and as such has essentially uncoupled the flow statistic from the ecological attribute of concern; <u>initiation</u> of bird breeding, because the flow threshold could occur before, during or after the breeding event, as long as it was within the hydrologic event. Despite this, the following discussion is based on the assumption, as is logical from the presentation in the documents that the "first" days of an event actually mean the first days of an event but the caveat noted here should always be remembered.
12. As examples of inappropriate extrapolations from the event definition, Brandis and Boni (p 54) state "However, the average duration of flow events at Narran Lakes Nature Reserve that have resulted in waterbird breeding is 275 days". They then recommend setting the minimum flow duration at 275 days. As noted above, this event duration does not "result" in waterbird breeding and, in terms of being an ecologically meaningful correlation is essentially unrelated to it. Also, to suggest that an average result should be used as the minimum target is unrealistic.
13. Brandis and Bino also state "This review has shown that the majority of Straw-necked ibis (the most numerous colonial species at Narran Lakes Nature Reserve) breeding events were associated with flow volumes in the first 90 days greater than 162,000 ML with an average duration of 275 days". Section 3.2.4 of Merritt et al states "This information provides evidence for a minimum requirement of flooding of between 73-94 days to support successful Straw-necked Ibis breeding." This appears to be the 66 days used in the Narran DSS of 2011 plus 10-28 days for nest building and a lag time to arrive since flood commencement. No ecologically meaningful link to the duration recommended by Brandis and Bino exists.
14. The documents report attempts to provide better hydrologic definition for the initiation of breeding. Section 3.3.4 of Merritt et al states "The likelihood of breeding initiation (Yes or No) is defined by the cumulative flow of the first 90 days of the flow event, the cumulative flow of the first 10 days of the flow event and the season". The results are generally expressed as being very positive "Using the extended record of Straw-necked Ibis breeding from 1971-2014 (27 breeding records in total over 18 of the 33 identified flow events – see Appendix 2) the CART analysis indicated that there was a probability of breeding of P = 1.00 (11 flow events, 11 breeding events) when total cumulative event flows exceeded 162,000 ML at Wilby Wilby in the first 90 days of the flow event." This is not an accurate representation of the results. When there are so few data points it is important that each

point is adequately checked and quality assured. While there has not been time to do a full check in this review, some clear errors and questionable results are readily apparent.

15. One example is that the 11 flow events actually incorporate 15 of the breeding events (due to the long hydrologic events capturing multiple breeding periods).
16. The 27 breeding events shown in Appendix 2 of Merritt et al include 4 specifically from Narran Lake, 2 from combined surveys of Narran Lake / Narran Lakes Nature Reserve and 21 separately from the Nature Reserve. The DSS modelling only related to the Nature Reserve and the combined results, so to a maximum of 23 events. Exclusion of Lake results from the DSS is appropriate because the event definition relates to a depth which is specifically relevant to the reserve and not the Lake.
17. Of those 23 events, Appendix 2 reports a breeding event for SNI in March 2001 (based on Kingsford pers.comm). Appendix B of Brandis and Boni in reporting records of breeding of all species on the reserve and lake only reports Banded Lapwing as breeding in 2001, that is, there is no record of SNI breeding at that time. Even so, the breeding survey was in March and the hydrologic event (event no. 27) ended in February so the allocation of this as a correct result from the model is not correct (unless the authors were using the estimated commencement of breeding rather than the survey time, but this is apparently not the case). Hence we have at best 22 events explained by the hydrologic models rather than 27.
18. Appendix 6 of Merritt et al notes “Note that Straw-necked Ibis breeding commenced in early January (c. 10,681 nests) prior to the start of flow event 30 but this was a failed nesting attempt with birds re-nesting successfully over March-June 2010 (c. 13,303 nests) following large inflows from mid-February to early April 2010. Cumulative flows at Wilby Wilby were only 1,763 ML over 1/1/10 to 16/2/10 prior to the start of flow event 30. They were detected opportunistically during an aerial survey on 18 January 2010 of the Castlereagh catchment as there was regional flooding in the nearby Castlereagh catchment and 250 mm of rainfall was recorded at Clear Lake (Terrill 2010).” Clearly this record is also not explained by the models and the 27 breeding events linked to the 18 flow events is actually 21. The other issue regarding this opportunistic observation is how many similar breeding events went unrecorded?
19. Similarly the statement in Section 3.3.5 of Merritt et al “When compared with observed data from 1971-2014, 100% of breeding was correctly predicted” cannot be correct because the breeding events of March 2001 and January 2010 were not predicted. The authors correctly note that the upgraded DSS predicted a further 5 breeding events which did not occur.
20. Section 3.3.5 also states “However, with only 27 breeding records available, and information on start and end times of breeding and estimates of total nest numbers not consistently recorded for all events, predictions of the size of breeding (nest numbers) in response to flow variables remain highly uncertain.” This actually understates the problem because while 27 records may have been available, they didn’t actually even use that number.
21. It was difficult to validate some of the other statements because base data was not provided, or when apparently relevant data is reviewed, it does not correlate well with the presented summary results or comments. For example Figures 13A and B of Merritt et al show the relationship between flow events / breeding events and the 162 GL and 18 GL flow thresholds. It is assumed that the graphed data is drawn from Appendix 6 with the breeding records drawn from the survey month and year presented in Appendix 2. Potential problems with the data in Appendix 6 are discussed below.
22. A cumulative flow over 10 days cannot be greater than a cumulative flow over 90 days using the same event start date yet this occurs 5 times in the 33 events in Appendix 6 (events 3, 7, 23, 27 and 28) and 3 of these are breeding events. There could be any number of

explanations for the error but it must be an error. Figure 13B (18 GL threshold) largely, but not completely reflects the relevant column of data in the Appendix. For example event 10 is shown on the figure as not exceeding the 18GL threshold but in the Appendix it does (23.9 GL) and this was a non-breeding event (which if true would weaken the statistical association as indicated by Figure 13B). The same occurs with event 26. The opposite occurs with event 24 which exceeds the threshold in the Appendix but not in the Figure and this was a breeding event.

23. Figure 13A bears little resemblance to the data in Appendix 6. This suggests the error is most likely in the Appendix figures for 90 day cumulative flows. If the Appendix 6 figures for the 90 day cumulative flow are correct then the figure and the statistical discussion of the relevance of this threshold would be incorrect as would the scenario analysis conducted using the DSS.
24. While it is more likely that Figure 13A is correct, the data for event 8 (Nov to Dec 1975) does not correlate with that shown on Figure 14A (total event flows).
25. Figure 13A, if correct, supports the statement that 11 hydrologic events are above the 163GL threshold and they all correspond to SNI breeding events. However 4 of these events only just exceeded 162GL and if a more precise definition of the hydrologic event were achieved, along with separation of each breeding event into a single hydrologic event, any correlated flow threshold would be less than 162GL. Also 7 breeding events occurred at substantially lower flows than 162GL in the first 90 days. As such, any 90 day flow figure for a flow event that related reasonably to actual initiation of breeding would be substantially lower than 163GL.
26. Just why the model using 162 Gl in the first 90 days and 18GL in the first 10 days (model or formulation 3) was determined as the “best fit” is unclear. Merritt et al state with respect to results in Table 9 that: “Re-substitution error rate identifies the best fit model”. If this holds for Table 8 then the model with the best Re-substitution error (rt) rate is model 1, which uses flow at Wilby Wilby as the start and end of the event, a cumulative flow of 116 Gl as the primary indicator and a cumulative flow of 29Gl as the secondary. That model also has the best result for the “accuracy” measure while model 4 has the best result for “precision” (because it uses the on-site gauge indicator rather than an upstream flow gauge as the start of event measure) and model 3 for “sensitivity”.
27. If the determination of “best” is related to the probability of breeding according to CART (footnote 2 to Table 8), then this is somewhat arbitrary and tends to favour the higher flows. Put simply, if one were to draw a line across Figure 13A at a point above which only breeding events occur, this would give you a breeding probability of 1.00. This level is 162GL and any volume you may wish to select above this figure also results in a breeding probability of 1.00. At 162GL 11 breeding events (or hydrogically defined events which contained breeding) occurred. A flow of nearly 500,000GL would also give a probability of 1.00 but only relate to one breeding event. If one lowers the flow trigger to 116GL on Figure 13A (and unfortunately as there is no reliable tabulated data I must estimate the volume from the columns), a further 2 breeding events are captured but so also are two hydrologic events which did not result in breeding. This is what lowers the CART breeding probability to 0.79 but is that the result upon which emphasis should be placed? The CART breeding probability of 1.00 estimates <u>certainty</u> of breeding but is unrelated to <u>initiation</u> of breeding (because at least 7 breeding events were initiated at flows below 162GL). Initiation occurs at a much lower levels and it is appropriate that the authors looked for shorter term, start of flood triggers.
28. It seems logical that an “event” based on the front end of a flood would be a better predictor of breeding initiation than a 90 day flow, mainly because breeding events (when each is separately analysed) usually start within a few weeks of flow commencement. Figure 13B of

Merritt et al shows this threshold was associated with 12 breeding events, so one better than the 90 day threshold.

29. However the 10 day threshold was also met on three occasions when breeding did not occur (so a false prediction) and breeding occurred on 6 occasions when the trigger was not met for a total of 12 right and 9 wrong.
30. Further, the breeding event of March 2001 is counted as a successful prediction but as noted above, either the event did not actually occur or it is outside the hydrologic event so is a failure. Also as noted above the event of January 2010 is outside the period of any hydrologic event so is a failure to predict. The summary is then 11 right and 11 wrong, again no better than a coin toss.
31. Brandis and Bino state "18,000 ML in the first 10 days was also critical". The word "critical" would suggest that it was essential or must be provided but given the discussion above, the flow could not possibly be regarded as critical.
32. Section 3.2.1 of Merritt et al states " A second breeding threshold was also identified where flow volumes in the first 10 days from the beginning of flow event were greater than 18,000 ML there was a breeding probability of P = 0.67 (9 flow events, 6 breeding records)." As noted, Figure 13B shows 15 flow events, 12 containing breeding. Perhaps the difference is that the figure includes some which were not "from the beginning of the flow event" but occurred at some other time within the event.
33. As noted, each of the thresholds in its own right is not a good predictor of initiation of breeding so should not be used for that purpose but further, they are simultaneously associated with only 6 of the apparent 18 events. This indicates that even if one were to recommend their use, they should not be both recommended, as has been done by Brandis and Boni.
34. Other inconsistencies between representations of data either in the same report or between reports were noticed. For example Appendix B of Brandis and Boni should contain the same breeding records for SNI as their Table 2 and also with Appendix 2 of Merritt et al but it does not. For example Table 2 reports 400,000 nests of SNI at Narran Lake in 1983 while Appendix B reports 200,000 nests on the Narran Lakes Nature Reserve while Appendix 2 reports 200,000 nests from two survey events at a combined Lake / Reserve location. Appendix B reports no records from the Lake prior to 1991 but Table 2 and Appendix 2 both report data from 1978 and 1983. Table 2 reports 260 nests at the Lake in 1978 and no count on the Reserve (which if true means it should not have been included in the DSS analysis) however Appendix B reports it as from the reserve only and Appendix 2 includes it as a combined Lake/Reserve count. Appendix 2 reports breeding in March 2001 but Appendix B does not and instead reports what might be the same event as occurring in 2000.
35. Merritt et al state "The size of colonies was variable ranging in size from 50 nests in 1981 (Brooker 1993) to 131,442 nests in 2012 (Spencer *et al.* 2015a)." However the 1983 count of 200,000 nests was always regarded as the highest ever in Australia but as there were two surveys that year and only 1 count is reported, the count may be cumulative. Given the surveys were conducted in July and November they probably represent 2 separate breeding events, which may indicate Spencer et al managed to split the count such that it is no longer the largest event. Alternatively it is simply another error.
36. The Brandis and Boni report contains numerous spelling errors, incorrect cross references to tables and figures, incorrect labels on figures and missing references.
37. Brandis and Boni also suggest "This review has shown that the majority of Straw-necked ibis (the most numerous colonial species at Narran Lakes Nature Reserve) breeding events were associated with flow volumes in the first 90 days greater than 162,000 ML with an average

duration of 275 days (~9 months). Our analyses also showed that flow volume in the first 10 days was also important for Straw-necked ibis. 18,000 ML in the first 10 days was also critical, <u>and increases in flow duration increased the probability of Straw-necked ibis breeding and the probability of breeding by other waterbird species</u>" (underline added). Unfortunately their review did not address the relationship of those other waterbird species to the modelling conducted specifically for SNI and specifically in the Nature Reserve so the "event" as modelled for SNI is of no relevance to these other species. For example the duration of suitable habitat conditions for these species may not be related to the gauge in Back Lake so the flow events and their associated durations and volumes may be unrelated to the needs of the species.

38. These other species do not have the same habitat, nesting or feeding requirements as SNI so they may be served by Narran Lake itself or sections of the Narran River rather than the reserve. Pelican or Black Swan for example are highly likely to rely more upon the lake, which retains substantial water long after "the event" in the Reserve has ended.
39. The origin of the assumptions being tested here is not specifically nominated and its relevance is dubious. The longevity of the species, the necessary frequency of successful breeding, the preference for Narran Lakes as opposed to other breeding areas etc are all relevant to a discussion concerning whether any emphasis should be placed on other species.
40. That most species in Figure 16 of Brandis and Boni have rarely or infrequently been recorded breeding at the reserve in the 42 years of record is a strong indicator that the reserve is not the preferred or a critical breeding area for the species and only occasionally suits them, keeping in mind the period of record is predominantly in pre-development condition or close to it.
41. Also given that the average "event" duration which coincided with SNI breeding is 275 days and the recommended flow duration required for successful colonial waterbird breeding across a range of species is 140-168 days (Figure 12), and the SNI duration occurs much more often than many of these other species have bred at the reserve, is a strong indicator that the issue is not one of significant concern.
42. Table 25 of Merritt et al shows that the duration of events associated with particular flow thresholds at Wilby Wilby remains essentially the same despite varying levels of water extraction. Even disregarding the large standard deviation, the duration of "events" is the same in without development and baseline scenarios. Duration of event per se, using this event definition, is not an issue.
43. The authors have spent almost all of their time assessing the upper end flows that have coincided with breeding events but have spent very little time on those events which occurred at lower flows than their nominated thresholds or in fact were not related to a flow event at all (January 2010), despite these events constituting nearly half of the Narran Reserve breeding events relating to one or other of the thresholds.
44. The data from Narran Lake showed breeding in April 1991 and it was a zero flow event. Breeding also occurred in December 1996 but it is not within an identified hydrologic event (so theoretically no flow trigger).
45. Brandis and Boni note "A total of 54 species of waterbirds have been recorded breeding at Narran Lake and Narran Lakes Nature Reserves since 1971." However Thoms et al 2007 (quoted in the EWR) said 45 species and the Ramsar Information Sheet says 44 so either one of them is wrong or an additional 9 or 10 species have bred there from 2008 – if so, that would tend to suggest that the lakes are performing well despite the drought and water resource development.

46. Merritt et al appropriately recognise errors and sources of data inconsistency in IQQM, other models and raw data.
47. Figure 36 of Merritt et al shows that the number of SNI breeding events predicted by the DSS (using 120 years of IQQM output) in the Existing Recovery scenario (which represents the current situation) is 75% of the without development scenario. This level is often regarded as acceptable in water resource development (e.g. the much used 2/3rd natural rule of thumb).
48. Further, increasing water recovery by 90GL (to the Northern Standard) only increases the proportion of breeding events to 78% (or by 2 events). A cost benefit analysis could not possibly support such increased recovery on this basis.
49. Moving to the MDBA 2800 SDL uses a further 63GL to generate an additional 7 events and move to 88% of pre-development.
50. Rather than using this relatively coarse approach to increase the number of events from the Existing Recovery level, it is probable that the same or a better outcome could be achieved by real time management of actual breeding events to ensure that if triggered to a substantial event they are completed with high fledging success, as was the 2008 event. This would leave far more water available for productive use and still achieve the desired increase in waterbird breeding success. As stated previously, smart water management should not simply be about how much water we manage, but how we manage water.

Suggestion

It is clear that breeding events are not only triggered by flow events and the flow events to which the trigger might actually relate are not large volumes (10 days for 18GL). Once an event has started it is also maintained by water level, possibly to some extent by flow and to other regional factors. Maintaining depth in the reserve is within the capacity of water resource managers and requires little water due to the relatively small volumes in the lakes of the reserve or the intervening storages. The events of 2008 clearly showed that it required little volume to manipulate a good breeding outcome from an event. It is this real time reactive approach which should be fostered, particularly given the uncertainty of any of the figures otherwise put forward.

Given that nearly half of all recorded breeding events occurred at flows less than those recommended by the authors, it is events at this level which can most readily be managed to ensure that they are successful events.

How far in advance of a flood can the level or potential duration be predicted?

ATTACHMENT E

Review of Water Requirements for Key Floodplain Vegetation

Casanova, Michelle T. (2015) Review of Water Requirements for Key Floodplain Vegetation for the Northern Basin: Literature review and expert knowledge assessment. Report to the Murray–Darling Basin Authority, Charophyte Services, Lake Bolac.

- The report is based on a literature review and expert knowledge assessment. No new field data was collected or analysed.
- The report does not use hydrologic data at all and does not refer to any specific flow levels, frequencies or durations related to the Lower Balonne nor does it specifically refer to Site-specific ecological targets and associated flow indicators for the Lower Balonne River Floodplain System developed by MDBA. As such, it is difficult to find a relevant conclusion or recommendation.
- The review focuses on five floodplain plant species – River Red gum (*Eucalyptus camaldulensis*), Black Box (*Eucalyptus largiflorens*), Coolibah (*Eucalyptus coolabah*), River Cooba (*Acacia stenophylla*) and Lignum (*Duma florulenta*).
- "Some species like River Red gum and Black box are well-studied (*at least in the south*). For the other species (Coolibah, River Cooba and Lignum) there have been fewer published studies, so the interview and workshop process was important for discovering information"
- "Little new information about how the Northern Basin vegetation water requirements differ from those of the Southern Basin vegetation was available. To the extent that it is available, science from the northern Murray-Darling Basin has been incorporated into this review. Appropriately, this knowledge has been complemented with studies from the southern part of the Murray-Darling Basin"
- "The main difference between the information provided by Roberts and Marston (2011) (*which was the key reference at the time the SFI's were set*) and the updated information in this review is the recognition of the influence of condition (referred to as *state* in the tables) on the water requirements of floodplain vegetation (after Overton *et al.* 2014). Floodplain vegetation can persist in declining condition for long periods of time when water is not provided. In general each species follows a decline pathway, progressing from *Good*, through *Medium, Poor* and *Critical* until *Death*. Restoration of the water regime required for vigorous growth (*sensu* Roberts and Marston 2011) for a single season does not generally restore the vegetation to a *Good* condition, if it has experienced severe decline (many years of water deficit). Some species are known to experience a different return pathway, via an *Intermediate* condition. Thus the number of years that water is not available impacts directly on the amount of water, and number of years of watering that must be provided to return the vegetation to good condition.
- "In summary, following the recommendations of Roberts and Marston (2011) for floodplain vegetation in the Northern Basin is likely to result in maintenance of the key species in the long-term. For the purposes of modelling, the frequency, timing and duration of flooding given in Roberts and Marston (2011) provide an adequate surrogate to describe the water requirements of the floodplain vegetation community (with the exception of submerged wetland and in-channel species). This review did not reveal evidence that the recommendations are inappropriate for the Northern Basin." Even the MDBA EWR documents modified the targets set by Roberts and Marston to reflect without development hydrologic conditions in the Lower Balonne e.g. they substantially reduced the required durations of flood events because they simply did not happen naturally in this region.
- "The water regimes outlined here for restoration of Good condition are necessary for the maintenance and functioning of floodplain vegetation". No evidence is presented to support the target condition being Good, and apparently Good at all times. Perhaps the natural

condition in some parts of the floodplain will be poor, in others it will be Good, that is, not every part of the floodplain occupied by a species is equally suitable to it. Certainly drought is natural and occasionally reduced condition of vegetation is also natural.

- This problem is seen in the "comprehensive tables" – the comments relate to specific studies in specific locations and the particular flooding regimes and other attributes relate only to that location. The result may not be transferable to other locations and particularly not the Lower Balonne.
- "Recent investigations in the northern Murray-Darling Basin (Holloway *et al.* (2013) citing Marshall *et al.* (2011)) have identified the occurrence of floodplain vegetation in areas that have dry spells (i.e. no overbank flooding) that exceed the duration of drought that the vegetation is supposed to be able tolerate (and suggesting therefore the published tolerance thresholds described within Roberts and Marston (2011) appear less applicable to these northern locations. Holloway *et al.* (2013) suggested that there are data showing that established populations of these species might be using groundwater, particularly during periods of reduced surface-water availability". These recent observations dispute the authors overall conclusion and support the action of the MDBA in originally modifying those thresholds to better reflect the local historic flow regime.
- Holloway actually said "However, recent studies by the Queensland government suggest that key floodplain vegetation asset species on the northern Basin may not be as reliant upon floodplain inundation for their maintenance and persistence phase as the published literature suggests. It should be noted that the majority of species specific life history information published in the literature has been derived from studies in the lower Murray−Darling Basin. Vegetation species from semi-arid areas have strategies to cope with stress during dry periods. The use of soil moisture created by groundwater and direct access to groundwater via their taproots are two such examples that may theoretically allow floodplain plants to supplement their water requirements during periods of stress."
- It appears Marshall and the team have been doing a lot of work over recent years which shows the Northern Basin is different. For example Marshall et al 2012 uses statements such as "Contrary to expectations based on the scientific literature", "This reliance on terrestrial production is inconsistent with what has been found in studies elsewhere and runs counter to our hypotheses." "The ecological responses to flooding in rivers of the northern Murray-Darling differed greatly from expectations built on studies from elsewhere. The results have fundamentally reshaped our understanding of the aquatic ecosystems in this region." The Lower Balonne is different and it is inappropriate to transfer knowledge from the southern basin and use it as a basis for management here other than in the broadest sense.
- The lack of understanding of the fundamental differences between southern and northern catchments is remarkable. "Season of flooding should be Winter-Spring (Rogers and Ralph 2011), although this information comes from studies in the Southern Basin. It is quite possible that flooding in Summer is still useful for trees in the Northern Basin, since that region naturally experiences higher Summer rainfall." Really, "quite possible"? If winter-spring floods were essential then these tree species would not be present in the northern basin, yet they are, in an environment which floods in summer and autumn. An opportunity was missed here was to weed out the comments that are likely to apply only to the southern basin as it risks confusion and inappropriate management decisions.
- The EWR (MDBA for the Lower Balonne) states "Floodwaters received in the Balonne River result from rainfall in the northern part of the Condamine–Balonne catchment and occur mainly in summer and autumn (NSW National Parks and Wildlife Service 2003). Flood

frequency is highly variable, occurring anywhere between several times a year to once every five years (Sheldon et al. 2000). The depth of the floodwater varies from a few centimetres to 10 metres and inundation of the floodplain can last for up to four months (Smith et al. 2006).” There is no point in a document including recommendations for flooding every 1-2 years and lasting 2-8 months because its not natural to this environment and not applicable.

- The literature review, which is the bulk of the document, simply quotes key lines from the various references but does not put them into context.
- There is far too much focus on southern information and the end result is “no change”.
- This sentence is common across reports so I assume was coordinated “To ensure the most efficient and effective use of environmental water, coordinated and targeted complementary actions need to be considered in an adaptive management framework that incorporates rigorous scientific monitoring and evaluation.”
- In summary, this review is actually a backward step from the existing SFI’s set by the MDBA other than noting that some documents are now showing that the Lower Balonne is different and that species here are possibly less reliant on river flooding than their southern counterparts.