Department of Science, Information Technology, Innovation and the Arts

Review of Water Resource (Warrego, Paroo, Bulloo and Nebine) Plan 2003

Environmental Assessment Report–Stage 1

October 2013

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1 Introduction

1.1 Background

The Water Resource (Warrego, Paroo, Bulloo and Nebine) Plan 2003 (the water resource plan) is approaching the end of its 10 year lifespan and is consequently being reviewed for replacement in 2014. The review of the existing water resource plan focuses on—

- Ensuring consistency with the Murray-Darling Basin Plan (Basin Plan) (for the Warrego, Paroo and Nebine)
- Maintaining consistency with the National Water Initiative
- Building on achievements of the water resource plan
- Ensuring that the new water resource plan meets requirements of stakeholders and the community
- Undertaking new hydrologic, environmental, cultural and socioeconomic assessments
- Consideration of climate change
- Consideration of any other relevant planning documents

The revised plan will continue the management of surface water and may include provisions for the management of groundwater.

1.2 Purpose of this report

The Environmental Assessment Report–Stage 1 (this report) is the first report in a two stage environmental assessment that, along with similar hydrologic, socioeconomic, and cultural assessments, is designed to inform the review of the water resource plan.

This report, has been prepared in accordance with the Environmental Assessment–Stage 1 terms of reference, and covers the following objectives:

1. identify surface water and groundwater dependent ecological assets in the plan area that:
    i. are vulnerable to water resource development and linked to both the ecological outcomes and objectives in the water resource plan and Warrego, Paroo, Bulloo and Nebine Resource Operations Plan 2006 (the resource operations plan)
    ii. reflect the Murray-Darling Basin Plan (consistent with the Basin Plan criteria and principles);
2. summarise monitoring outcomes relevant to the plan;
3. assess the effectiveness of the plan (over its life) in relation to its stated outcomes, strategies and objectives based on an analysis of item 3 above;
4. identify significant risks and issues from the assessment of items 2 and 3 above; and
5. provide recommendations for scenario testing and critical flow requirement assessments to form part of the stage 2 assessment.

1.3 Report outline

This report is a summary of information contained in two technical appendices and is structured as follows:

Section 2 – Overview of the plan area

Section 3 – Identification of surface water and groundwater dependent ecological assets in the plan area

Section 4 – Summary and analysis of relevant monitoring activities conducted over the life of the plan

Section 5 – An assessment of the effectiveness of the plan in relation to its stated outcomes, strategies and objectives based on an analysis of the relevant monitoring as above, including identification of risks and issues

Section 6 – Recommendations for scenario testing and critical flow requirement assessments to form part of the stage 2 assessment

Appendix A – Ecological asset selection report

Appendix B – Summary of monitoring report

2 Water resource plan area

The Warrego, Paroo, Bulloo and Nebine catchments comprise a total area of approximately 253 000 km^2 and straddles the Queensland and New South Wales border. The plan area for the water resource plan is comprised of the Queensland portions of the Warrego, Paroo, Bulloo and Nebine catchments which cover approximately 190 956 km^2 (DERM 2010a). The plan area is bounded to the west by the Cooper Creek catchment and by the Condamine and Balonne catchment to the east of the (Figure 1).

The main rivers include the Warrego River, the Paroo River, the Bulloo River, Nebine Creek, Wallam Creek and Cuttaburra Creek. The plan area is considered to be an arid region, with rainfall varying widely both spatially and temporally. The Warrego and Paroo Rivers feed various wetlands, including floodplain wetlands, freshwater wetlands and saline lakes (Kingsford et al. 2002). During large floods, these two rivers as well as the Nebine and Wallam Creeks drain into the Darling and Culgoa Rivers of the Murray-Darling Basin (MDB) in north-west New South Wales. The Bulloo River terminates at Bulloo Lakes in Queensland and does not form part of the Murray-Darling Basin.

Industries in the plan area include beef cattle, sheep (for wool), bee-keeping (Paroo), opal mining (Bulloo and Paroo) and natural gas production (Bulloo) (Cottingham 1999). There is little surface water resource development in the plan area with a maximum of only 13% of pre-development flows being diverted for the consumptive use under water allocations. There is very little irrigated cropping consisting primarily of some water extraction for cotton and horticulture (Warrego catchment) as well as for cattle fodder crops.

The Cunnamulla Water Supply Scheme (Cunnamulla WSS) is the only water supply scheme in the plan area supplying 28 water allocations with a total nominal volume of 2612 ML. There are 51 unsupplemented water allocations within the plan area with a total nominal volume of 51 112 ML.

This volume includes 9000 ML of water that has been allocated to the Commonwealth Environmental Water Holder under three water allocations.

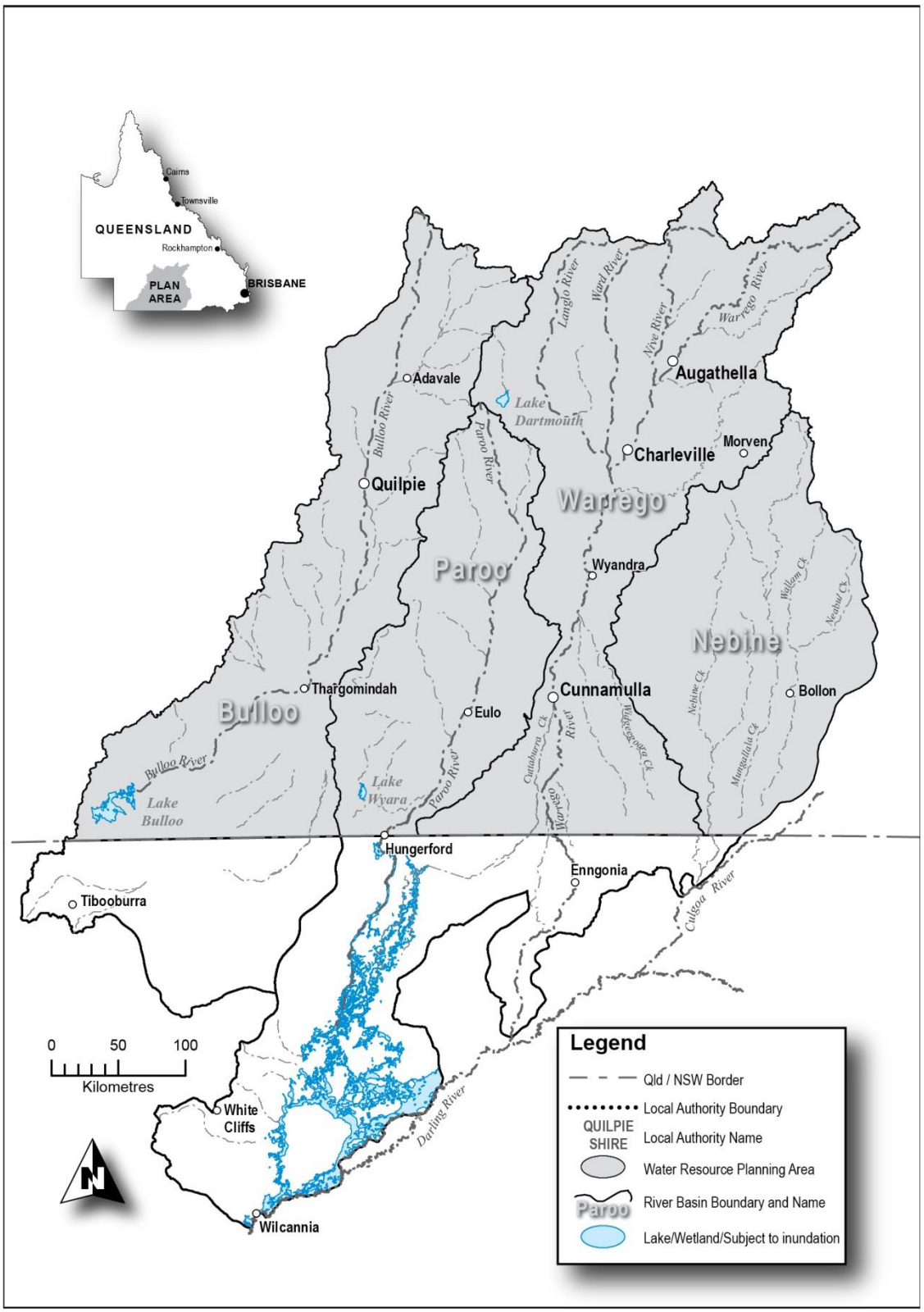

Figure 1. Warrego, Paroo, Bulloo and Nebine Water Resource Plan area

3 Ecological assets in the plan area

3.1 Background

Water resource plans include a number of strategies designed to achieve stated outcomes aimed at protecting and, where possible, enhancing the ecological integrity of a water resource plan area. However, measuring the success of these strategies is complicated by interactions between biota, habitat and hydrology at multiple scales. As water resource plans can only manage the flow, capture and take of water, the influence of flow on ecosystems must be separated from the influence of other factors. The monitoring and assessment approach taken is based on the following principles:

- Ecosystem condition is influenced by a range of factors, and flow is only one of these.
- Ecosystem components respond to the local hydraulic habitat conditions (for example, depth, velocity, water quality) where flow interacts with river morphology and other features.
- The flow requirements of specific ecosystem components can be used as indicators of the broader ecosystem.

Therefore the environmental assessment focuses on the critical water requirements of the ecosystem and whether these are being met. 'Ecological assets' are selected as indicators to represent the flow-dependent ecosystem and ecological outcomes in each water resource plan. An ecological asset is an ecosystem component that occurs naturally in the water resource plan area, is critically linked to flow and dependent on the conditions provided by flow to support its long-term integrity. An ecological asset may be a species, a group of species, a biological function, an ecosystem or a place of natural value. The objectives of using ecological assets in the environmental assessment are to:

- select indicators representative of each aspect of the flow regime as well as the ecological outcomes of the plan
- determine if current flow management strategies in the water resource plan are providing the critical flow requirements of ecological assets (and hence the ecosystem);
- determine the potential risk to ecological assets in the water resource plan area under various flow management scenarios; and
- evaluate if the water resource plan is achieving its stated ecological outcomes through current flow management strategies, or if changes or additional strategies are required.

It is important to recognise that the ecological assets adopted for assessment of management scenarios for a water resource plan are carefully selected for this purpose, but they are not necessarily more important to the ecosystem in general, or more valued by society, than other ecosystem components that do not make the final list. They are selected to serve the purpose as indicators of ecosystem response to flow or groundwater regimes. Each water resource plan contains a unique set of ecological outcomes and ecological assets that are relevant to the plan area; consequently ecological assets selected for each will differ across the state.

3.2 Surface water ecological assets

3.2.1 Methods

Surface water ecosystem components and processes relevant to the plan area were identified from a review of the scientific literature, information from technical reports (including earlier asset

selection work carried out for the plan, DERM 2011), guidelines, action plans, regional ecosystem mapping, government databases, and through consultation with relevant local experts and stakeholders. Information on the ecosystem component's location/distribution, status under state and commonwealth legislation, and critical links to surface water, was also collated. The broad list of ecosystem components was then reduced based on available information, to a set of prioritised ecological assets that were critically-linked to the flow regime, had well-understood specific flow requirements, and were potentially threatened by water resource development. Further details of this process are presented in Appendix A.

3.2.2 Results

A list of 2937 ecosystem components was compiled for the plan area, including waterhole habitats, wetlands, river forming processes, and species of fish, amphibians, reptiles, mammals, birds, invertebrates and plants with a potential link to flow. This initial list was reduced to a subset of 95 surface water ecological assets based on available information about each component's critical link to flow.

Further analysis of the these ecological assets and introduced species identified a prioritised list of nine assets (see Appendix A Report) which were considered to be both vulnerable to the types of flow regime change that could potentially occur under the water resource plan and have sufficient information available about them to set flow management rules (eco-hydraulic rules). These were prioritised for the ecological risk assessment to be undertaken in Stage 2 of the Environmental Assessment (Table 1). In some instances, where flow requirements are similar and data is patchy (e.g. stable-flow fish, floodplain wetlands) a number of assets were grouped together. One introduced species–the European carp–was also selected, with the aim to assess how well each of the scenarios may affect reductions in carp populations. The prioritised assets rely on the provision of critical hydrologic conditions including: refuge waterhole persistence, in-channel flows, bankfull discharge for sediment mobilisation, inundation of floodplains and wetlands, and appropriate longitudinal and lateral connectivity.

Overall, the prioritised assets represent or support all of the water resource plan ecological outcomes, require a broad range of flow conditions from low flows to floods, and as a suite, address the environmental asset and ecosystem function criteria as set out in the Murray-Darling Basin Plan (MDBA 2012). Further details of these results are presented in Appendix A.

Table 1. Prioritised surface water ecological assets for the water resource plan area

Asset name	Common name (if applicable)	Type	Catchment	Water resource plan ecological outcome	Basin Plan criteria	Value	Associated values	Key aspects of flow required
Active river-forming processes, including sediment transport		Ecosystem process	W, P, B, N	9f (iv)		Deep waterhole habitat for aquatic biota	Habitat for fish, birds, plants, reptiles and amphibians during dry spells Deep waterholes provide habitat for Murray Cod (*Maccollochella peelii peelii*) which is listed as vulnerable	Bankfull discharge
Flow spawning fish species		Ecosystem component – fish	W, P, B, N	9f (i, iii, vi, vii)	5.5	Population viability within WPBN of : *Macquaria ambigua (yellowbelly), Macquaria sp. (Bulloo yellowbelly), Neosilurus hyrtlii (Hyrtl's tandan), Porochilus argenteus (*Silver tandan), *Leiopotherapon unicolour (spangled perch), Bidyanus bidyanus (silver perch), Scortum barcoo (*Barcoo grunter), *Bidyanus welchi (*Welch's grunter)		Seasonal in-channel flows
Floodplain terrestrial vegetation species		Ecosystem component – plant	W, P, B, N	9f (iii, vi, vii) 9j	5.5	Healthy floodplain vegetation within WPBN of: *Acacia stenophylla (*River cooba), *Eucalyptus coolabah* (Coolibah), *Eucalyptus largiflorens* (Black box) *Eucalyptus ochrophloia* (yapunyah gum) *Duma florulenta* (Lignum)	Good health is a prerequisite for reproduction; healthy vegetation canopy provides habitat for many invertebrates, reptiles, birds and mammals, including the vulnerable Bulloo Grey Grasswren *(Amytornis barbatus barbatus*) in Lignum	Floodplain inundation
Chelodina longicollis	eastern snake-necked turtle	Ecosystem component – turtle	W, B, N	9f (i, iii, vi, vii) 9j	5.5	Population viability of *Chelodina longicollis* (eastern snake-necked turtle)		Floodplain inundation
Wetlands (Permanent and temporary)		Ecosystem process – habitat	W, P, B, N	9f (ii, iii, v, vii) 9g, 9j	5.1, 5.2 (those in Currwinya NP and Culgoa Floodplain NP), 5.3, 5.5, 6.1	Maintenance of wetland habitats within WPBN	Waterbird breeding habitat International conservation (Ramsar, JAMBA, CAMBA, RoKAMBA, Bonn) Habitat for fish, birds, plants, reptiles and amphibians	Floodplain inundation

Asset name	Common name (if applicable)	Type	Catchment	Water resource plan ecological outcome	Basin Plan criteria	Value	Associated values	Key aspects of flow required
Absence of exotic fish species	European carp	Ecosystem component – fish	W, P, B, N	9f (iii, vii)	5.5	Low abundance of exotic *Cyprinus carpio* (European carp) in the WPBN area	Low carp abundance has positive influence on the viability of many other native aquatic species	In-channel flow variability
Genetic diversity of aquatic biota in the Bulloo		Ecosystem component	B	9f (vi)		The unique genetic diversity of aquatic biota in the Bulloo	Biodiversity of the WPBN	Inter-basin water transfers
Migratory fish species		Ecosystem component – fish	W, P, B, N	9f (i, iii, vi, vii)	5.5	Population viability within WPBN of : *Macquaria ambigua (yellowbelly), Macquaria sp. (Bulloo yellowbelly), Tandanus tandanus (eel-tailed catfish), Bidyanus bidyanus (silver perch), Leiopotherapon unicolour (spangled perch), Neosilurus hyrtlii (Hyrtl's tandan), Bidyanus welchi (Welch's grunter), Porochilus argenteus (silver tandan),*		Longitudinal connectivity
Permanent waterholes		Ecosystem process – habitat	W, P, B, N	9f (i, ii, iii, iv, vii) 9g	5.3, 5.5, 6.1	Refugia for fish, turtle and invertebrate population viability for species including: *Macquaria ambigua (yellowbelly), Macquaria sp. (Bulloo yellowbelly), Neosiluroides cooperensis (Cooper Creek catfish), Tandanus tandanus (eel-tailed catfish), Maccullochella peelii peelii (Murray cod), Bidyanus bidyanus (silver perch), Leiopotherapon unicolour (spangled perch), Nematalosa erebi (bony bream), Neosilurus hyrtlii (Hyrtl's tandan), Hypseleotris* spp. (carp gudgeon), *Melanotaenia fluviatilis (southern rainbowfish), Melanotaenia splendida tatei (desert rainbowfish), Mogurnda adspersa (purple spotted gudgeon), Retropinna semoni (*Australian smelt), *Ambassis agassizi (glass fish), Scortum barcoo (*Barcoo grunter), *Neosilurus pseudospinosus (*Falsespine catfish), *Porochilus argenteus (*Silver tandan), *Bidyanus welchi (*Welch's grunter),	Habitat for fish, birds, plants, reptiles and amphibians such as *Limnodynastes peronii* (striped marsh frog) during dry spells. Deep waterholes provide habitat for Murray Cod (*Maccullochella peelii peelii*) which is listed as vulnerable	Waterhole persistence

Asset name	Common name (if applicable)	Type	Catchment	Water resource plan ecological outcome	Basin Plan criteria	Value	Associated values	Key aspects of flow required
						*Chelodina longicollis (*eastern snake-necked turtle), *Emydura macquarii macquarii (*Murray turtle), *Emydura macquarii emmotti (*Cooper Creek turtle), *Cherax destructor* (yabby), *Macrobrachium australiense (freshwater prawn), Velesunio spp. (freshwater mussel) and Notopala sublineata (a snail).*		

3.3 Groundwater dependent ecological assets

Three classes of groundwater dependent ecosystems (GDEs) were considered in the asset identification process (after Eamus et al. 2006):

- aquifer and cave systems (karstic, fractured rock, alluvial aquifers, hyporheic zone)
- ecosystems dependent on the surface expression of groundwater (baseflow, non-riverine wetlands, and mound springs)
- ecosystems dependent on the sub-surface expression of groundwater, often accessible via the capillary fringe when roots penetrate this zone (terrestrial vegetation).

3.3.1 Methods

Groundwater dependency was considered for each of the three classes of GDEs. Due to the lack of information available for the WPBN, information from past sampling of groundwater aquifers in other northern Murray-Darling basin catchments outside the plan area was interrogated to determine if physical or chemical characteristics of the aquifers correlated with patterns in the occurrence of subterranean invertebrate fauna that inhabit groundwater (stygofauna). To identify possible GDEs, springs were identified from maps developed by the Queensland Wetland Program and their attributes reviewed to determine those linked to aquifers relevant to the plan. Groundwater depth was then mapped throughout the plan area using data on Queensland Government monitoring bores. This was intersected firstly with the location and depth of wetlands to identify those that may be linked to groundwater, and secondly with vegetation communities (Regional Ecosystem types–REs) with roots deep enough to reach the groundwater. This was used to identify potential groundwater dependent vegetation communities and to determine plan areas where there was unlikely to be any GDEs. The Bulloo catchment had very few monitoring bores, so GDEs were identified by extrapolating the distributions of RE types identified as potential GDEs in the other three catchments. Further details of these methods are presented in Appendix A.

3.3.2 Results

3.3.2.1 Stygofauna

Stygofauna in other Queensland Murray-Darling Basin aquifers were found to occur in aquifers with widely varying water quality and structural features (DERM, unpublished data), meaning it was not possible to identify particular characteristics of aquifers associated with stygofauna presence/absence or composition. This suggests that all aquifers in the water resource plan area may possibly harbour stygofauna, and that investigations are needed to document stygofauna occurrence in the plan region. Further details of these results are presented in Appendix A.

3.3.2.2 Springs

Springs were present in all catchments within the plan area; however all were identified as Great Artesian Basin springs dependent on the surface expression of groundwater from that aquifer. As such, none of these springs are affected by the Warrego, Paroo, Bulloo and Nebine water resource plan and are not considered further in this assessment.

3.3.2.3 Non-riverine wetlands

The assessment concluded that none of the many non-riverine wetlands across the plan area are potentially dependent on groundwater because they are shallow–generally less than 2 m (Andrew Biggs, pers comm), and do not intersect with aquifers in the region, all of which were recorded to have depth to water table deeper than 2 m. Further details of these results are presented in Appendix A.

3.3.2.4 Terrestrial vegetation communities

The assessment identified 68 types of REs as potentially dependent upon groundwater in the plan area. Within Queensland, these potential GDEs occupied 26% of Warrego catchment, 38% of the Paroo catchment, 17% of the Bulloo catchment and 31% of the Nebine catchment. Dominant plant species comprising these REs included *Acacia aneura, Acacia cambagei, Eucalyptus populnea, Eucalyptus ochrophloia* and *Eucalyptus coolibah* growing on residuals, alluvial plains and sandplains. Patches of these REs were classed as either likely or possible GDEs based on the depth of underlying groundwater projected from monitoring bores. In the Bulloo catchment there were very few monitoring bores so there is less certainty regarding the groundwater dependency of vegetation in this catchment. Further details of these results are presented in Appendix A.

4 Summary of monitoring

4.1 DNRM Monitoring

4.1.1 Water resource plan/resource operations plan monitoring

The current water resource plan allows only minor changes to flow regimes from their pre-development state and so is considered to pose a relatively small risk to aquatic ecosystems and their associated values in comparison to other those of other Queensland Murray-Darling Basin catchments (DERM 2011). Consequently, no ecological monitoring specific to the WPBN plan was conducted by the Queensland Government over the life of the plan. However, monitoring and research conducted in other MDB catchments by the Queensland Government and others (Appendix B) on ecological assets common across the region has informed scientific understanding of the flow requirements of a subset of the ecological assets in the water resource plan catchment, namely golden perch, waterholes and river red gum. This work has concentrated on understanding flow requirements related to:

- the reproduction and recruitment of golden perch (*Macquaria ambigua*) (DERM 2010b)
- the movement behaviour of fish between waterholes when flow events pass down dryland rivers (DERM 2010c)
- waterhole persistence during spells without flow and the function of waterholes as drought refuges (DERM 2010c)
- the responses of populations of floodplain vegetation communities, fish and aquatic food-webs to floods (Woods et al. 2012).

4.1.2 Water quality monitoring

Queensland and New South Wales government monitoring programs have collected water quality data from both surface waters (Appendix B) and groundwaters (McNeil & Raymond 2011) in the

plan area. Surface water physical and chemical properties were found to broadly be within Queensland Water Quality Guideline (DERM 2009) values throughout the region indicating good water quality. Electrical Conductivity (EC) and turbidity were identified as useful indicator parameters for monitoring because many other attributes of the water correlate with them. Trends in these two parameters over the past ten years suggest that EC was increasing in the site assessed in the Warrego, but remained stable at the assessment site in both the Bulloo and Paroo, while turbidity increased in the Warrego and Paroo but was stable in the Bulloo.

Groundwater monitoring in bores accessing subartesian supplies identified salinities up to 60 000 µS/cm, but mostly in the range 1000–2000 µS/cm. These subartesian aquifers are not affected by the water resource plan.

4.1.3 Riverine condition and trend assessment

The Queensland Government has conducted assessments of the ecological condition of waterways in the WPBN for the MDBA Sustainable Rivers Audit (SRA) (Davies et al. 2012) and a process to identify and prioritise threats to aquatic ecosystems in the region using an ecological risk assessment process (Marshall et al. 2006; Negus et al. 2009, 2012). Ecological condition assessment for the SRA concluded that the Warrego and Paroo catchments are in good condition based on their physical form and riparian vegetation. Instream biota condition varied over time with the condition of fish communities consistently poor to very poor in the Warrego, and consistently good in the Paroo. The condition of aquatic macroinvertebrate communities was good in both catchments during 2008–10, but poor in the Warrego and moderate in the Paroo during 2004–2007. The Nebine and Bulloo catchments were not assessed by SRA. Further details of these results are presented in Appendix B.

A threat prioritisation undertaken as part of the Queensland Government Stream and Estuary Assessment Program (SEAP) (Negus et al. 2012) identified that threats unrelated to water management posed greater risks to the condition of ecosystems in the WPBN than any of the potential threats from altered flow regimes. Overall, three threats were considered to pose a medium to high risk to the condition of ecosystems in the region:

1. instream pest fauna (carp, goldfish and Gambusia)
2. riparian pest fauna (including pigs and goats)
3. deposited sediment in persistent waterholes.

Of the threats that are potentially managed by the plan reduced persistence of waterholes from pumping (both licensed and stock and domestic) was the highest. However, the risk to ecosystems was assessed as being low because of the few waterhole pumping entitlements at the scale of the plan area. This threat prioritisation indicates that the risks being managed by the plan are low in context of other types of threats and highlights the low risks to ecosystems posed by flow regime modification in the plan area.

4.2 Resource operations licence holder monitoring

Monitoring, assessment and reporting conducted by SunWater, the resource operations licence holder under the requirements of the water resource plan indicates that in Cunnamulla Weir storage water quality consistently fell within Queensland Water Quality Guideline (DERM 2009) values for electrical conductivity, dissolved oxygen, pH, nitrogen and phosphorus, but occasionally nitrogen and phosphorus concentrations were above guideline values during no-flow periods. Fish and turtle strandings have occurred as a result of water ponding against road infrastructure

downstream of Allan Tannock Weir and installation of a fishway on the weir is being considered to prevent recurrence of these incidents. The Department of Agriculture, Fisheries and Forestry (DAFF) and dam operators, SunWater, are responsible for the maintenance of infrastructure and fish passage at Cunnamulla Weir including mitigation of the fish and turtle stranding.

4.3 East Australian Waterbird Survey

The East Australian Waterbird Survey provides some of the only long-term objective data on waterbird populations in Australia (Porter & Kingsford, 2011 and references there-in). Changes in the distribution and abundance of 50 waterbird species have been recorded in October each year for 27 years (commencing 1983) across 10 survey bands, each 30 km wide, that extend from the coast of eastern Australia to the Northern Territory border and from the Whitsunday Islands in Queensland to south of Melbourne. Results provide evidence that the reproduction and recruitment of waterbirds coincides with widespread river flooding and particularly a series of floods over a large areas of Australia. Most of the long-term variability in total waterbird abundance over the Australian continent can be explained by the occurrence of very large-scale rainfall systems that propagate from the tropics to the interior (Padgham 2011). This highlights that local water management is not at the same scale as processes governing waterbird population dynamics and viability. Thus, in general, the plan can contribute to local conditions suitable for waterbird breeding, but is not solely responsible for the overall population viability of these species.

5 Preliminary assessment of the effectiveness of the water resource plan and resource operations plan based on results of monitoring

The summary of monitoring suggests that the plan has been successful in meetings its ecological outcomes and objectives. The findings of existing monitoring programs do not indicate negative impacts from water resource management strategies in the plan area.

Water quality parameters were generally within guideline values and the ROL holder monitoring did not identify any significant water quality or ecological issues. The SRA scores indicate fluvio-geomorphology, riverine vegetation and macroinvertebrate communities are in good condition in both the Warrego and Paroo catchments. Fish communities in the Warrego are considered in poor condition; however the SRA study design does not allow the source of impacts to be identified, so the role of flow management is unknown. Eastern Australian Waterbird Survey results indicate that the reproduction and recruitment of waterbirds coincides with widespread river flooding and particularly a series of floods over large areas of Australia. Most of the long-term variability in total waterbird abundance over the Australian continent can be explained by the occurrence of very large-scale rainfall systems that propagate from the tropics to the interior. Existing monitoring programs are unable to assess whether ecological outcome 9(f)(vi), relating to maintenance of the unique genetic diversity of the Bulloo Basin has been achieved, however because the plan does not allow for interbasin transfers of water, this value is not currently threatened by water resource management activities.

In terms of the range of threats to aquatic ecosystems in the plan area, a qualitative risk assessment process indicated that the risks posed by flow regime modification are low (DSITIA 2012). The findings of relevant monitoring associated with each of the plan outcomes are listed in Table 2.

Table 2. Assessment of plan ecological outcomes

Monitoring Programs	Monitoring findings	WRP outcomes	Comments
DNRM SWAN monitoring	Surface water physical and chemical properties were found to broadly be within Queensland Water Quality Guideline values throughout the region indicating good water quality.	9(f) (i,ii) 9(g) 9(k)	Monitoring data suggest that water quality in pool and riverine habitats is being maintained at an appropriate level for water use and to support ecological processes, and in line with Murray Darling Basin commitments and agreements.
ROL holder monitoring by SunWater at Allan Tannock Weir	ROL holder operational reports do not indicate any instances of fish stranding and kills or blue-green algal growth Allan Tannock Weir or watercourses associated with the operation of the Cunnamulla Water Supply Scheme. However, fish and turtle strandings have occurred as a result of water ponding against road infrastructure downstream of the weir and installation of a fishway is being considered to prevent recurrence of these incidents.	9(f) (i,ii) 9(g)	ROL holder monitoring data suggest that the operation of Alan Tannock Weir is not affecting water quality, habitat quality and aquatic biota. Fish and turtle strandings downstream of the weir are concerning, but barrier remediation of this type is outside the scope of the water resource plan.
	ROL holder operational reports submitted by SunWater do not indicate any instances of bank slumping within Allan Tannock Weir or watercourses associated with the operation of the Cunnamulla Water Supply Scheme.	9(f)(iv)	ROL holder monitoring data suggest that the operation of Alan Tannock Weir is not significantly affecting river-forming processes, such as erosion.
SRA (fluviogeomorphology, riverine vegetation, macroinvertebrate, fish themes)	The SRA scores indicated the Warrego and Paroo catchments are in good fluviogeomorphic condition. The riverine vegetation was assessed as being in good condition for both the Warrego and Paroo catchments. Similarly the macroinvertebrate communities were assessed as being in good condition. In the Warrego catchment, the condition of fish communities was assessed as being in poor condition. In the Paroo catchment, the condition of fish communities was assessed as being in good condition.	9(f) (i,ii,iii,iv)	SRA monitoring data suggests that pool and riverine habitats, geomorphological processes, and aquatic, riparian and floodplain biota are generally being maintained in the Paroo and Warrego catchments. However, fish communities in the Warrego catchment were identified as in poor condition. The design of the SRA does not allow for the identification of causative stressors. Further assessment is required to determine whether water management strategies are contributing to poor fish condition in the catchment.
Eastern Australian Waterbird Survey	Eastern Australian Waterbird Survey results indicate that waterbird populations are driven by drought and flood cycles. The reproduction and recruitment of waterbirds coincides with widespread flooding associated with large-scale rainfall systems.	9(f) (i,ii,iii,v,vii) 9(j) 9(l)	EAWS monitoring data suggest that wetland flooding and waterbird breeding opportunities are being maintained, however the climate conditions (e.g. widespread drought and monsoonal flooding) that control long-term variability in waterbird populations are at a much broader spatial scale than that managed by the WRP. The plan therefore has limited capacity to control the provision of waterbird requirements.

6 Recommendations

The review of monitoring conducted over the life of the plan has not identified any ecological issues that would suggest the need for any significant changes to the intent of the new water resource plan and resource operation plan. However, a more detailed analysis of potential impacts from water management will be conducted as part of the risk assessment in Stage 2.

The ecological asset selection process has identified a suite of nine assets which are both representative of the ecological values of the plan area and the outcomes of the existing plan. Furthermore they represent the intent of the Murray-Darling basin plan and are therefore consistent with its outcomes.

It is recommended that these ecological assets be the focus of the stage 2 environmental assessment process to evaluate the water resource plan/resource operations plan. In stage 2, risk from water resource management will be assessed by comparing the provision of the hydrologic conditions required by the ecological assets selected in stage 1, under predevelopment and management flow scenarios. Outcomes of these analyses will provide information to further refine the ecological outcomes and strategies for the new water resource plan and resource operation plan.

7 References

Bennett, J 2008, Final discussion paper on implementation of the national water quality management strategy (NWQMS), in consultation with the NWQMS Contact Group, Department of Environment, Water, Heritage and the Arts, Australian Government, Canberra.

Cottingham, P 1999, Scientific forum on river condition and flow management of the Moonie. Warrego, Paroo, Bulloo and Nebine river basins, Queensland Department of Natural Resources and CRC for Freshwater Ecology, Brisbane.

Davies, PE 2012, SRA Report 2: Report by the Independent Sustainable Rivers Audit Group to the Murray-Darling Basin Ministerial Council, Murray–Darling Basin Ministerial Council, Canberra.

Department of Environment and Resource Management 2009, Queensland Water Quality Guidelines Version 3, Queensland Government, Brisbane.

Department of Environment and Resource Management 2010a, Queensland's water resource plans: annual report 2009-10, Queensland Government Brisbane.

Department of Environment and Resource Management 2010b, Environmental conditions and spawning of golden perch (Macquaria ambigua Richardson, 1845) in the Border Rivers, Queensland Government, Toowoomba.

Department of Environment and Resource Management 2010c, Refugial waterholes project research highlights. Queensland Government, Brisbane.

Department of Environment and Resource Management 2011, Asset selection report: Water Resource (Warrego, Paroo, Bulloo and Nebine) Plan 2003, Queensland Government, Toowoomba.

Department of Science, Information Technology, Innovation and the Arts (DSITIA) 2012, Risk assessment and threat prioritisation: Bulloo, Paroo, Warrego and Nebine catchments, Queensland Government, Brisbane.

Eamus, DE, Hatton, T, Cook, P & Colvin, C 2006, Ecohydrology: vegetation function, water and resource management, CSIRO Publishing, Collingwood, Australia.

Kingsford, RT, Brandis, K, Young, B & Fryar, S 2002, Environmental flows on the Paroo and Warrego Rivers: Progress Report Year 2, Environment Australia, Canberra.

National Water Quality Management Strategy (NWQMS) 1994, Policies and principles, A reference document, Agriculture and Resource Management Council of Australia and New Zealand, in conjunction with the Australian and New Zealand Environment and Conservation Council.

Marshall, J, McGregor, G, Marshall, S, Radcliffe, T & Lobegeiger, J 2006, Development of Conceptual Pressure-Vector –Response Models for Queensland's Riverine Ecosystem, Aquatic Ecosystems Technical Report No. 57, Department of Natural Resources Mines and Water, Brisbane.

McNeil, VH, & Raymond, MAA, 2011, Inland Waters–Groundwater Technical Report, Department of Environment and Resource Management, Brisbane.

Murray Darling Basin Authority 2012, Proposed Basin Plan— A revised draft, Commonwealth of Australia, Canberra.

Negus, P, Moller, G, Blessing, J, Davis, L, Marshall, J & Dobbie, M 2009, Stream and Estuary Assessment Program – an assessment framework for riverine ecosystems, Department of Environment and Resource Management, Brisbane.

Negus, P, Blessing, J, Clifford, C, Steward, A, Hansen, D & Hammill, B 2012, Stream and Estuary Assessment Program Risk Assessment and Threat Prioritisation: Warrego, Paroo, Bulloo and Nebine catchment, Department of Science Information Technology, Innovation and the Arts, Queensland Government, Brisbane.

Padgham, M 2011, 'Relating climatic dynamics in time and space to ecological responses, with application to Australian waterbirds', Ecosystems, vol. 14, pp. 94–111.

Porter, JL & Kingsford, RT 2011, Aerial Survey of Wetland Birds in Eastern Australia - October 2011 Annual Summary Report, NSW National Parks and Wildlife Service, Office of Environment and Heritage.

Woods, RJ, Lobegeiger, JS, Fawcett, JH & Marshall, JC (eds) 2012, Riverine and floodplain ecosystem responses to flooding in the lower Balonne and Border Rivers – Final Report, Department of Environment and Resource Management, Queensland Government, Brisbane.

Glossary of terms

Term	Definition
baseflow	Stream flow sustained by shallow groundwater sources between rainfall events (sometimes called low flow or groundwater recession flow)
biota	The organisms that occupy the plan area
critical link to flow	Conditions provided by the flow regime which are related to a critical life history or ecosystem process i.e. spawning and recruitment, river forming processes.
eco-hydraulic	An aspect or aspects of the flow regime that are relevant to an ecological asset
ecological asset	An abiotic or biotic component of an ecosystem, hydrology, geomorphology, riparian vegetation, aquatic vegetation, aquatic macroinvertebrates, fish, other vertebrates.
ecological component	A biotic component of the ecosystem such as riparian vegetation, aquatic vegetation, aquatic macroinvertebrates, fish, other vertebrates
ecological integrity	A measure of an ecosystem's ability to be self-sustaining over the long term.
ecological outcome	As defined in the *Water Act 2000*, i.e. “means a consequence for an ecosystem in its component parts specified for aquifers, drainage basins, catchments, sub-catchments and watercourses.” Comparable to “management goal” in the WQM process.
ecological value	Taken in its broadest sense. It includes not only the aquatic biota (fish, invertebrates, macrophytes) but also the biota of the riparian or foreshore zone, the river habitats and geomorphology. It is also taken to include the river processes, both physical and biological, and the roles a river may play in sustaining other systems such as, karst, estuary, floodplains and wetlands. The concept of an ‘ecological value’ relates particularly to the ‘aquatic ecosystems’ environmental value.
ecosystem health objective	Combines measurable biological parameters (e.g. number of macroinvertebrate taxa) with chemical and physical water quality parameters.
guideline	Numerical concentration limit or narrative statement (water quality) recommended to support and maintain a particular objective (NWQMS 1994; Bennett 2008).
indicators	A property that is able to be measured or decided in a quantitative way (Environmental Protection Policy for Water 1997, section 8)
performance indicator	A measure that can be calculated and is stated in a water resource plan to assess the impact of an allocation and management decision or proposal on water entitlements and natural ecosystems (*Water Act 2000*, Schedule 4).
Regional Ecosystem (RE) types	Refers to the groundwater dependent ecosystem types as determined by Queensland Regional Ecosystem (RE) mapping
resource operations plan	A plan approved under s103(2), (*Water Act 2000*, Schedule 4)
riparian	Habitat situated on the bank of a water body
stygofauna	Fauna that live within groundwater systems, such as caves and aquifers
values/assets	The perceived value of the environmental, economic, social attributes of an ecosystem.
water quality	The status of an aquatic ecosystem (including surface, soil and groundwater), including physical, chemical, biological and aesthetic characteristics. (after NWQMS 1994; Bennett 2008)
water quality objectives	Measurable outcomes which when met will maintain all of the environmental values and management goals for a particular waterway. They are

	quantitative, usually numerical or narrative values. For example, if one of the environmental values of a waterway is irrigation, the salinity of the water needs to be kept below a specific concentration (the water quality objective). (after NWQMS 1994; Bennett 2008)
water quality parameter	A measurable or quantifiable characteristic or feature of water quality e.g. pH, conductivity, nutrient concentration, etc.
water resource plan	A plan approved under s50(2), (*Water Act 2000*, Schedule 4)