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SUBMISSION TO THE HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON REGIONAL AUSTRALIA

Inquiry into Certain Matters Relating to the Proposed Murray Darling Basin Plan

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Executive Summary

1. The role that works and measures projects could play under the Basin Plan

Works and measures projects are investments in improved productivity and/or water savings within the river system. They are sourced from the environmental water pool, and deliver environmental benefits without requiring a reduction in sustainable diversion limits (SDLs) for human use. Works and measures afford the opportunity to invest our way to a better future rather than simply divide up what we currently have. Further advantages of works and measures, include the potential to:

- Optimise socioeconomic outcomes as required under the Water Act.
- Avoid the costs of adjustment for people that are not captured in economic models.
- Target investment directly to optimise environmental outcomes.
- Meet multiple objectives other than water recovery, including environmental, socioeconomic, and cultural benefits.
- Provide large scope for beneficial projects. For example, efficiency improvements of just 1 per cent per year would equate to 190 GL per year or 1,900 GL over a period of 10 years.
- Deliver benefits through combination with strategic purchases.
- The potential for greater stakeholder participation, consensus, and continuous improvement given appropriate time and an ongoing institutional structure and processes to support projects.

2. Prospective works and measures projects

MI recommends that the first project proposal for works and measures is their inclusion within the proposed Basin Plan: as a strategy to enable optimisation of socioeconomic and environmental outcomes, within the modelling to establish the primary targets of the Basin Plan, and water accounting and reporting. Other potential works and measures projects that should be considered include:

- Infrastructure and water management systems to minimise the need for overbank flows.
- Drought management plans to maintain appropriate ecosystem refuges and watering during droughts.
- Reductions in losses to waste, and improve drainage, storage and return flows during floods.
- Use of consumptive use infrastructure to deliver water to off-river environmental assets.
- Promote complementary water uses through, for example, investment in the use of wetlands as on-route storages and piggy backing of flows.
- The progression of the proposed Lowbidgee (Nimmie-Caira) project in the Murrumbidgee.
- Introduction of necessary measures to enable greater use of strategic water purchases such as the *RiverReach* project.
- Investments in identifying and mitigating: factors that are constraining ecosystem responses to improved water flow health, and non-beneficial losses from the environmental water pool.
- Direct investment in projects to: reduce invasion by exotic species, promote native species, improve water and land management practices, and improve environmental water management.
- Improve the coordination between jurisdictions, States, and the Commonwealth for ongoing identification, formulation, evaluation, and implementation of works and measures in the Basin.

MI has always worked with other stakeholders in the Valley to help identify and formulate specific projects to deliver works and measures. We will continue to do so if given the time and opportunity.

1. The potential role that new environmental works and measures projects could play in partially offsetting SDL reductions under the Basin Plan

Works and measures projects are investments in improved productivity in the use of water to deliver water savings within the river system. Such projects usually involve improvements in infrastructure (assets and technology) and/or productivity (management systems and practices) to enable us to deliver more environmental benefits with available water and/or reduce losses of water to low benefit use and waste.

Works and measures are therefore very similar to investments in water savings in off-river irrigation delivery systems and on-farm. The major differences are that works and measures savings:

- Are sourced from the environmental water pool rather than the 'consumptive' water pool that is diverted from rivers for human use.
- Deliver increases in the effective volume of water for the environment and/or environmental benefits without requiring a reduction in sustainable diversion limits (SDLs) for human use.

Like all water savings works and measures increase the total benefits to the nation from the given quantity of water available to the Murray-Darling Basin (MDB). They expand the effective water resources subject to new sharing arrangements under the proposed Basin Plan. Rather than relying on 'zero sum' re-allocation of water to the environment via purchase or acquisition from the consumptive pool, works and measures enable us to increase the environmental share while making the MDB 'cake' bigger for everyone.

In simple terms works and measures affords the opportunity to invest our way to a better future rather than simply divide up what we currently have. There are several further advantages.

1.1 Potential to optimise socioeconomic outcomes

Like off-river water savings works and measures enable optimisation of outcomes for both the environment and people reliant on the Basin's water resources for their livelihoods. This is extremely important because it is a primary objective of the Water Act and the Basin Plan.

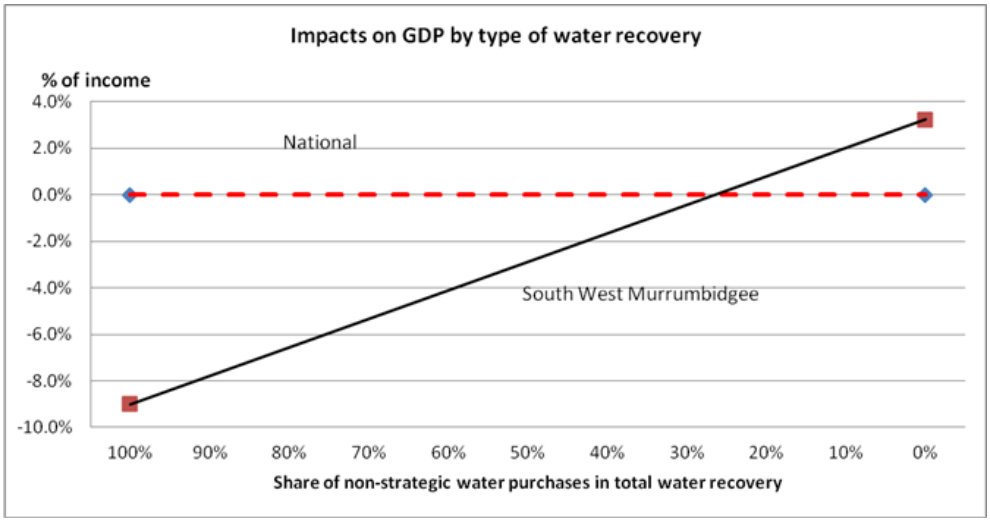
The following chart shows the impacts on income for both the South West Murrumbidgee (SWM) and for the nation for each share of non-strategic purchases in total water recovery for the environment under the proposed Basin Plan. If non-strategic purchases are 100 per cent of SWM water recoveries then income in the SWM can be expected to fall permanently by about 9 per cent, while the impact on national income is close to zero. But if all of the water recovered is via works and measures and off-river savings in irrigation delivery systems and on-farm[1] then the SWM could expect a permanent expansion in incomes of about 3 per cent while the impact on the rest of the nation would be slightly negative in percentage terms.[2]

The data between the polar cases (i.e., 100% recovery by purchases and 100% by water savings) is presented assuming linearity of impacts between the polar cases. That assumption needs to be tested through specific modelling, but the chart provides a simple example of how water savings through works and measures can be used in concert with water purchases to help optimise outcomes for regional communities.

MI recommends that a similar approach to be taken to assist the Parliament to optimise socioeconomic outcomes and guide improvements to the strategy reflected in the proposed Basin Plan.

[1] The socioeconomic impacts of works and measures and off-river water savings are virtually the same, except that regional communities would benefit more from off-river savings through additional investment and economic activity within the region. Works and measures, however, would benefit the region of location for the works and measures.

[2] The data on these polar cases are drawn from a report by Independent Economics "Modelling the Economic Impact of the Draft Basin Plan", 13 April 2012. The report was commissioned by a group of Murrumbidgee Valley stakeholders including Murrumbidgee Irrigation and was prepared by Chris Murphy, one of the leading CGE modellers in Australia.



Source: "Modelling the Economic Impact of the Draft Basin Plan", Independent Economics, 13 April 2012 for data points of 100% and 0%. The estimates between these cases are simply assumed to be linear between the polar cases.

1.2 Potential to avoid the costs of adjustment for people in regional communities

CGE models do not fully capture the costs associated with adjustment to the loss of water to irrigation based communities. These include the cost to individuals and families of unemployment, search costs for new employment, relocation expenses and financial losses, costs associated with decline in health and welfare, and many non-quantifiable costs associated with major social and cultural change. Other important costs include underutilisation of immobile capital such as water delivery systems (Swiss cheese effects) and stranding of social and economic assets as people leave the area.

To the extent that water is recovered via works and measures these costs are avoided.

1.3 Potential to target investment to optimise environmental outcomes

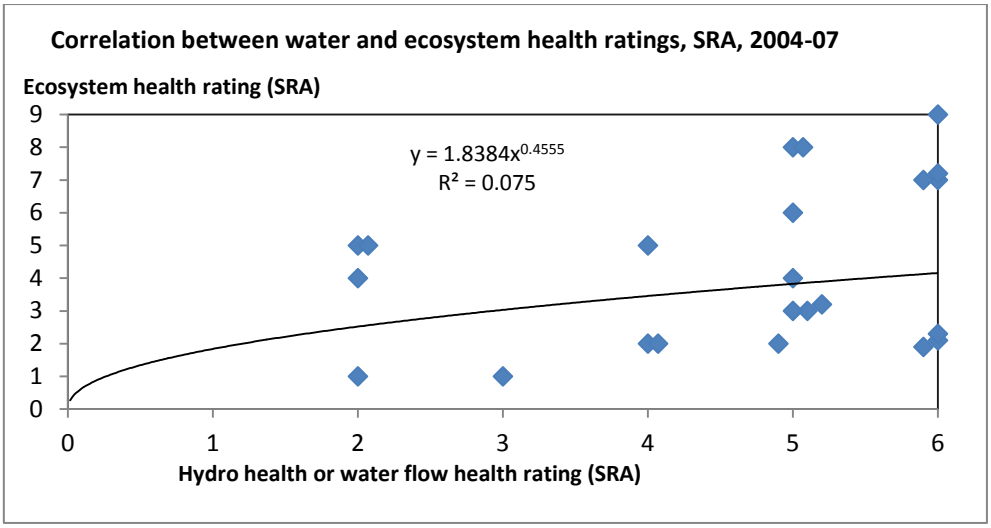
The following chart shows the very low correlation between the ratings of water flow health (hydrological health) and ratings for ecosystem health for the Basin valleys assessed by the Sustainable Rivers Audit (SRA, 2004-07). This poor link between water and ecosystem health strongly suggests that:

- Many environmental problems in the MDB are caused by factors unrelated to water, or by the timing of water availability to the environment (such as insufficient water to maintain resilience of ecosystems to drought). These include impacts of invasive species such as European carp, and land and river management activities.[3]

- There may be significant constraints to achieving objective environmental benefits from the water that has been recovered (at quite high financial cost). This is supported by the MDBA acknowledgement that "the current level of understanding of ecological responses to environmental health water is relatively poor" (p69 of the Guide volume 1), and the poor recovery of the condition in the lower lakes following the last two years of above average flows for the Basin (Adelaide Advertiser 7 March 2012).

These problems can be addressed through fit-for-purpose works and measures projects, and suggest that works and measures projects must be a key element of the strategy the Basin Plan if we are to meet the objective of optimising environmental outcomes as demanded under the Water Act.

[3] See tables 3.10 and 3.11 of "Report of the River Murray Scientific Panel on Environmental Flows, River Murray Dartmouth to Wellington and the Lower Darling", June 2000, (attached).



Note: SRA refers to the sustainable rivers audit, 2004-07. The rating of 6 for hydrological health is the highest and 0 is the lowest. The rating of 9 for ecosystem health is the highest and 0 is the lowest. The ratings are altered slightly to ensure data for each river is visible. This will alter the relationship but only very slightly. (Source: Tables 2.2 and 2.3 of the Guide to the Proposed Basin Plan, Volume 1.)

1.4 Potential to meet multiple objectives

In addition to meeting specific environmental objectives more efficiently and effectively than other water recovery options, works and measures can be formulated to meet multiple objectives more effectively than water purchases. Recovering water for environmental health in the MDB affects all of society. The market price of water only reflects the financial impacts that are felt only by the buyer and seller. It does not necessarily encompass external environmental, social, and cultural impacts - and can be a very 'blunt instrument'. Investment projects in water savings, however, can and should incorporate socioeconomic, environmental, and cultural impacts and outcomes.

MI's own Barren Box Storage and Wetland (BBSW) project is a good example. On financial grounds the Government might find that rather than invest in this project it would be cheaper to just buy water. But the BBSW project is yielding significant environmental benefits aside from water savings (through rehabilitation of the natural wetland and salinity mitigation), socioeconomic benefits (by maintaining regional production), and cultural benefits (through re-invigoration of an Aboriginal historical site). These additional benefits mean that a comprehensive assessment would heavily favour investment in the BBSW project rather than straight out water purchase.

1.5 Potential from the large scope for beneficial works and measures projects

The large volume of water, the vast catchment area, the large number of water regulation assets and management systems, the number and size of environmental assets involved, and the multitude of stakeholders and regulatory agencies within the MDB suggest huge scope for works and measures benefits if we are able to better coordinate efforts from local jurisdictions through the States and to the Commonwealth.

For example, the volume of water that is potentially subject to works and measures – the environmental water pool including losses – is about 19,000 GL according to the MDBA (Schedule 2 p80 of the "Plain English Summary" to the proposed Basin Plan). This means that efficiency improvements of just 1 per cent per year would recover effective water for the environment of 190 GL per year or 1,900 GL over a period of 10 years. A volume of water such as this would negate the need for any further water purchases, and – with well designed projects – meet multiple environmental, socioeconomic, and cultural targets much better than water purchases.

A Basin Plan that included works and measures as a central strategy would also provide a significant incentive to all stakeholders to participate in the formulation and implementation of those projects, and help to promote a culture of continuous improvement and coordination that would likely yield benefits to both people and the environment well into the future of the Basin. It would also help to minimise the current costs of fragmentation and friction within Australia's communities that has been such a feature of the current approach.

1.6 The potential benefits of combining works and measures with strategic purchases

The presence of very high volumes of non-strategic purchases introduces high costs and risks for investment in fixed assets and water management because water flows, assets and management practises throughout the MDB are heavily determined by the demands from water entitlement holders and the environment. MI has long argued for a joint program of combining investment in infrastructure (upgrades and rationalisations) and better coordination of water management with strategic water purchases to deliver the best outcomes for regional areas and the nation in the long run.

Within river systems the benefits of works and measures will likewise be undermined by non-strategic water purchases. The impacts may be less localised and visible than the costs associated with non-strategic purchase in off-river systems. However MI is of the view that there would still be very large benefits from formulating combined programs of works and measures and strategic water purchases rather than conducting these recovery programs in isolation, with focus on the blunt instrument of non-strategic water purchase.

1.7 The potential for greater stakeholder participation, consensus, and continuous improvement

Given time, a works and measures strategy for the MDB would help to harness greater stakeholder participation, promote more consensus about future directions, and facilitate a culture of continuous improvement that is necessary to keep pace with the changes in demands for water within the Basin.

MI's experience in identifying the equivalent of works and measures within our system suggests that water delivery systems are never static. Opportunities for new works and measures continually emerge and the nature of these projects change over time in response to prevailing circumstances and the availability of technologies. Also, investment programs take a long time to identify, formulate, and implement. Even quite simple changes in coordination of water management and rules can take time to implement because of the need to consult extensively with stakeholders.

A sound works and measures program is therefore unlikely to come about through a simple one-off exercise that requests stakeholders to make suggestions and then sift through those to identify feasible projects. Rather, we need time, a very good institutional framework, and supporting processes including criteria for approval and funding arrangements to enable ongoing project formulation and implementation.

2. Prospective project proposals identified by state governments and community interests

At present works and measures are practically invisible in the proposed Basin Plan while, ironically, playing an important part in the public debate surrounding that document. Leaving works and measures out of the Basin Plan is akin to leaving Government funded infrastructure investments and productivity improvements out of public sector planning for important sectors such as energy, utilities, transport, and communications.

MI therefore recommends that the first project proposal for works and measures is that works and measures be formally included within the proposed Basin Plan. There are three main ways that this can be accomplished:

1. Specific inclusion of works and measures as a strategy to enable optimisation of socioeconomic outcomes (as well as environmental outcomes).

   There are a number of ways to do this, but at its most simple all that is required is acknowledgement that SDL reduction is a formula equal to the target volume of water recovery for the environment less the volume of water recovered through works and measures. Alternatively the SDL itself could be set as a target volume – as in the current proposed Basin Plan - plus the volume recovered by works and measures. The potential role of works and measures investments should also be specifically envisaged within environmental plans.

2. Specific inclusion of works and measures within the modelling associated with establishing the primary goals and targets of the Basin Plan.

   The "natural conditions" scenario estimates water flows in the event that there are no diversions for consumptive use and the major regulatory structures within Basin rivers such as dams and weirs are removed. This approach is likely to significantly overstate the water flows and end-of-system flows under "natural conditions" because it excludes the huge range of works and measures that have been established in the Basin that act to increase returns to rivers and streams. These include:

   - Extensive systems to control floods within MDB rivers such as levees and land formation to confine water within floodways and redirect that water back into Basin rivers and streams.
   - The enhancements to rivers, floodways, and natural streams to improve their efficiency in collecting water flows and returns to Basin surface water systems.
   - Changes to land formation across the Basin reflecting the need for rapid application and removal of water to and from farms (such as laser levelling and tile drainage). These investments have arisen to improve the efficiency of the 'natural' landforms that were often seen to be inefficient in terms of application and drainage of surplus water.
   - Extensive changes to the Basin vegetation cover from natural conditions. Deforestation has significantly reduced the demands on Basin water resources by plants and – along with improved drainage systems – this would have significantly increased return flows to Basin water resources compared to natural conditions.

   It is probable that the current partial treatment given to works and measures is acting to significantly overestimate the volume of end-of-system flows required to deliver a sustainable and healthy Basin ecosystem. In these circumstances, especially after recovery of over 1,500 GL through water purchases and acquisition, it would seem reasonable to switch future recoveries to focus on works and measures if only to avoid unnecessary 'over-recovery' of water at high cost to regional communities through further SDL reductions.

3. Formal inclusion of works and measures in ongoing water accounting and reporting in relation to the total volume of water recovered for the environment and/or the impact on SDLs.

   The current water accounting and reporting of water recoveries under the proposed Basin Plan excludes information about works and measures. We are told that SDL reductions from 'prior efforts' (including

the Living Murray, the Water for Rivers, and Water Sharing Plans) have totalled 959 GL. Works and measures projects have been implemented as part of 'prior efforts' programs and have delivered significant water savings. But we are not told the volume of water saved through these projects. Separately, we are informed that works and measures have delivered 118 GL in effective water recovery.[4] The question is, how have those savings been included in the water recovery target and SDL reductions in the proposed Basin Plan? Since works and measures savings are sourced through either reducing the volume required to meet the demands of off-river environmental assets, or by improving the efficiency of return flows the current water accounting system clearly needs refinement in order to deal with this important recovery mechanism.

Other potential works and measures projects that should be evaluated and implemented subject to feasibility and given appropriate time include:

- Installation of appropriate channels/pipes and – possibly - pumping systems and water management systems to minimise the need for overbank flows and to ensure appropriate ecosystem refuges are maintained during droughts when watering the large number of Basin wetlands.

- The formulation and publication of drought management plans for key environmental assets to maintain appropriate ecosystem refuges and watering during droughts. This could include cellular management of lakes and wetlands as has been applied in the Barren Box Swamp project within the MI system.

- Improvements to current infrastructure to better manage water flows during floods in order to reduce losses to waste, improve drainage to avoid over-inundation, and improve storage and return flows for either better environmental outcomes or consumptive use.

- The use of existing consumptive use infrastructure to deliver water to off-river environmental assets such as the proposed use of the Lowbidgee (Nimmie-Caira) delivery system to water the Lowbidgee wetlands.

- Promote complementary water uses through, for example, investment in the use of wetlands as on-route storages and water management systems so that water can be delivered to multiple targets for both the environment and consumptive use (such as opportunities for piggy backing).

- The progression of the proposed Lowbidgee (Nimmie-Caira) project aimed at the strategic sale of significant volumes water entitlement along with the delivery system to enable large scale watering of the Lowbidgee flood-plain and wetlands without the need for overbank flows. This is a win-win because the additional water is complemented immediately with an efficient delivery system to the off-river environmental assets (effectively becoming works to deliver in-river savings). In addition, there seems to be quite good prospects for eco-tourism associated with the expected enhancement of the Lowbidgee wetlands and floodplain.

- Introduction of necessary measures to enable greater use of strategic water purchases such as the *RiverReach* project. *RiverReach* was developed by MI with funding from the Water Smart Australia project. It provides for contracts that enable entitlement owners to sell or term-lease an agreed volume of water based on conditions that lessen the costs to the seller in terms of foregone production, and the purchase cost to the environment. *RiverReach* allows people to retain their licensed entitlement but forward sell their annual allocation for an agreed period based on allocation triggers. MI estimates that this type of product could deliver as much as 250,000 ML[5] across the southern connected system of the Basin. Other potential products include buy and lease-back products. The Commonwealth should also be active in the temporary water market as both a buyer

[4] See "Comparison of Water Course Diversion Estimates in the Guide to the Basin Plan with other Published Estimates", MDBA, Nov 2011.
[5] Estimate based on a survey of large private and government irrigation businesses as part of the 'RiverReach' project under the Water Smart Australia program, 2009

and seller. Unfortunately, roll out of this proposal is being constrained by organisational and management constraints.

- Investments aimed at improving the environmental benefits from the existing environmental water pool (including recoveries to date) such as:
  - Research into the factors that are constraining ecosystem responses to improved water flow health and specific targeting of future works and measures projects on removal of those constraints.
  - A comprehensive investigation of all losses from the environmental water pool in the Basin along with assessment of how those losses can be reduced in order to deliver increased environmental water benefits.
- Direct investment in strategies and projects to:
  - Reduce or eliminate invasion by species such as European Carp.
  - Promote native species through works such as fish ladders and measures to improve habitat conditions within the current system.
  - Improve water and land management practices throughout the Basin to complement water recovery initiatives to date.
  - Improved environmental water management, including the very difficult areas such as managed 'cease-to-flows'.
- Projects to improve coordination between jurisdictions, States, and the Commonwealth to improve coordination of water management (collection, storage, flows, and drainage recovery) and related infrastructure and management rules. This is likely to significantly improve efficiency of delivery and reduce losses.

In summary, MI has runs on the board when it comes to delivering outcomes for the environment without compromising other values. The recovery of 20,000 ML of water savings to the Snowy system through the redevelopment of Barren Box Swamp, and formulation of the *RiverReach* proposal to enable more strategic low cost sale of water to the environment are just two examples of recent projects. It is worth remembering that MI water use comprises about 1,000 GL on average compared to about 19,000 GL under the Basin environmental pool. If works and measures within that pool could emulate just the Barren Box project then 380 GL could be saved.

There is also good evidence to suggest that we can optimise both environmental and socioeconomic outcomes if we are given the necessary support and time to formulate and implement sound projects.

MI has always worked with other stakeholders in the Valley to help identify and formulate projects to deliver in-river water savings through works and measures. We will continue to do so, and stand ready to cooperate with the Commonwealth in these endeavours if given the opportunity.

Attachment: Extracts from "Report of the River Murray Scientific Panel on Environmental Flows, River Murray Dartmouth to Wellington and the Lower Darling", June 2000

TABLE 3.10 Flow management activities that threaten the key components of river–floodplain ecosystem health – habitat diversity, natural linkages and metabolic functioning

Flow Management Action	Ecosystem Health Component	Observed and Predicted Ecological Impacts
Constant flow for sustained periods	Habitat Diversity	Erosion and incision of riverbanks Change in bed morphology Reduced range of bank habitats May favour exotic species
	Metabolic Functioning	Reduced epiphytic productivity Change in vertical temperature profile Loss of cues for invertebrate reproduction probable Loss of cues for fish movement Loss of cues for plant reproduction
Unseasonal flow	Habitat Diversity	Habitats not available when needed Degradation of habitats through death of native species, promotion of invasive species and lack of regeneration of native species
	Natural Linkages	Linkage is made ineffective – timing of flow triggers is critical as they often work in association with other triggers such as increasing temperature or daylight hours Changes in transport of particles and biotic material
	Metabolic Functioning	Reduced light penetration through increased turbidity and depth which affects instream productivity Change in sediment transport regime Change in vertical temperature profile Lack of oxic processes if natural drying out phase of floodplain is prevented
Increased minimum flow	Habitat Diversity	No natural drying out leading to a loss of ephemeral habitat Loss of instream habitat diversity necessary to maintain biological diversity May favour exotic species Degradation of natural low flow channel shape Changes to instream habitat
	Metabolic Functioning	Reduced benthic productivity if too deep Lack of oxic processes if natural drying out phase of floodplain is prevented
Decreased frequency of flooding periods	Habitat Diversity	Reduced and even lost species requirements for reproduction and regeneration Loss or redistribution of habitats
	Natural Linkages	Reduced input of organic material from floodplain to river resulting in reduced fish reproduction success
	Metabolic Functioning	Reduced exchange of organic carbon, nutrients, sediment, etc., between floodplain and river
Reduced duration individual floods	Habitat Diversity	Critical life cycle stages cannot be completed Reduced recharge of floodplain and/or bank Changes to natural rate of morphological change
Rapid rates of rise of fall	Habitat Diversity	Bank slumping causing erosion and loss of habitat, while resulting siltation smothers and degrades habitat Stranding of biota and/or habitats leading to deaths
Weir pools	Habitat Diversity	No natural summer drying out leading to a loss of ephemeral habitat Loss of instream habitat diversity necessary to maintain biological diversity May favour exotic species Degradation of natural low flow channel shape Alteration of instream habitat
	Metabolic Functioning	Stratified pools develop anoxic bottom water (if overflow weirs) Thermal stratification favours cyanobacteria

TABLE 3.11 River and land management activities (other than flow management) that threaten the key components of river–floodplain ecosystem health – habitat diversity, natural linkages and metabolic functioning

Ecosystem health component	Management Action	Observed and Predicted Ecological Impacts
Habitat Diversity	Grazing of riverbanks	Reduced ability for regeneration of native vegetation No refuges for biota Reduced snag input to river Value of bank as habitat for invertebrates and fish is lost May cause changes in vegetation, species and structure Increased bank instability
	Clearing of riverbank	Value of bank as habitat for invertebrates and fish is lost Loss of snag input to river
	Promotion of exotic riparian vegetation	Habitat value doubtful, particularly where willows replace native vegetation Loss of snag input to river in the future If canopy density is changed, then micro-climate and habitat changes will impact invertebrates Changed in-channel morphology and therefore habitat
	Removal of snags	Loss of structural habitats Loss of breeding sites for some fish species Loss of macroinvertebrate habitat Loss of channel diversity Loss of diversity of water depths and velocities
	Recreational boating	Bank erosion resulting in siltation that has a smothering impact on habitats Re-suspension is some areas Loss of in-channel benches
	Aggregate extraction	Change in bed morphology
Natural Linkages	Levees	Disrupt linkages
	Floodplain development	Devalues linkages – remaining linkages are less effective as development reduces area and quality of habitat
	Removal of snags	Loss of habitat and food substrate on floodplains, and input of this to the river
	Various land use practices	May lead to water quality changes that affects linkages – saline intrusions and blackwater build up to form a barrier to fish movement
	Culverts and regulators	Disrupt linkages Devalue linkages – remaining linkages are less effective as development reduces area and quality of habitat

Ecosystem health component	Management Action	Observed and Predicted Ecological Impacts
	On-stream storage structures	Linkage is made ineffective – timing of flow triggers is critical as they often work in association with other triggers such as increasing temperature or daylight hours Results in serial discontinuity (the river upstream of the structure is separated from the river downstream) which prevents fish movement and invertebrate drift, and obstructs the transfer of instream material downstream
Metabolic Functioning	Increase in diffuse nutrient sources	Increases severity of algal blooms May shift balance between allochthonous (eg terrestrial leaf input) and autochthonous (within stream) carbon inputs to the river, with resultant changes to biotic community structure
	Diffuse toxicant sources	Agricultural and industrial chemicals can have toxic effects
	Erosion and sediment input from catchment modification	Increased turbidity and siltation Absorption and transport of pollutants
	Clearing of riverbank	Reduces input of organic material, including leaves and snags Alters type and timing of carbon inputs, if bank replanted with non-native vegetation or shift in vegetation types occurs Increased sediment input
	Removal of snags	Loss of biofilm area and productivity for macroinvertebrates
	Temperature of releases	Decreases productivity especially if cold water being released in summer Modified cues for native fish breeding May favour exotic fish and other fauna Reduces opportunity for completion of life cycle as there are critical thresholds for hatching, germination etc. Can alter overall productivity
	Hypolimnetic (bottom)releases from storages	Potential effect on downstream productivity due to increasedconcentrations of nitrogen, phosphorus, iron, magnesium Potential effect on downstream microbial processes
	Aggregate extraction	Interrupts sediment transport