Environmental benefits and risk assessment for the Victorian Constraints Measures Program

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Key Points

- The first stage of the Victorian Constraints Measures Program (VCMP) feasibility study and the linked NSW Reconnecting River Country Project (RRCP) investigated the potential environmental benefits and risks from increasing the limit for environmental water delivery up to the minor flood level.
- The program seeks to improve the capacity of managers to achieve Basin Plan objectives, improve condition of the Southern Connected Basin and connectivity into SA, and increase localised environmental benefits from environmental water delivery.
- Environmental condition was found to improve in direct proportion to the level of constraints relaxation, with the larger relaxation scenario showing the greatest benefit.
- The benefits associated with these scenarios are directly related to the inundation of floodplain ecosystems.
- This assessment included a limited set of ecological values or 'themes' that aligned with both the expected outcomes in the Basinwide Environmental Flow Strategy and with the availability of existing environmental response models.

Abstract

The first stage of the Victorian Constraints Measures Program (VCMP) feasibility study and the linked NSW Reconnecting River Country Project (RRCP) investigated the potential environmental benefits and risks from increasing the limit for environmental water delivery up to the minor flood level. The program seeks to improve managers capacity to achieve Basin Plan objectives, improve condition of the Southern Connected Basin, connectivity into SA, and increase localised environmental benefits from environmental water delivery. Initial range finding of flow rates conducted for the Goulburn River determined potential scenarios, while Murray River scenarios were informed by RRCP. Ecological modelling was undertaken for vegetation, native fish, waterbirds, and geomorphology response, plus vegetation inundation, water quality, macroinvertebrates/production, and connectivity. Additionally, investigations were undertaken on the risks to achieving outcomes, and risks to the environment from the scenarios.

The lower relaxation scenarios indicated some disbenefits, with a reduction in uncontrolled releases impacting some outer areas of floodplain vegetation. Higher relaxation scenarios showed a likelihood of improved health for vegetation communities, and positive outcomes for all other environmental values investigated.

The outcomes support the feasibility of the VCMP by showing that relaxation of constraints has strong potential for environmental benefits. The results recognized the current decline in health for ecosystems that rely (or relied) on riverine flooding and the importance of constraint relaxation to help protect and sustain those environments. Project outputs will now inform consideration of project options for both rivers.

The use of environmental response modelling for the Victorian and NSW programs has been able to help show the feasibility of the project to deliver positive outcomes for the ecosystems that the river supports.

Keywords

Victorian Constraints Measures Program' Minor flood level, Environmental benefits, Beneficial Flooding

Introduction

River regulation and consumptive use of water have interrupted many of the natural river and wetland processes needed by native plants and animals to grow, reproduce, move, and ultimately survive. River regulation has significantly modified natural flow regimes, including the timing, duration, rates, and variability of flows. This modification has adversely impacted the condition of river systems, and the flora and fauna that depend on them for survival. The threat to water-dependent ecosystems and species within the MDB posed a substantive risk to the achievement of Australia's international treaty obligations to biodiversity conservation. In response, the Murray-Darling Basin Plan 2012 (the Basin Plan) was developed to improve the health of the river systems of the basin and its floodplains. The Basin Plan recognises the importance of connectivity through high flows and includes "healthy and resilient ecosystems with rivers and creeks regularly connected to their floodplains" as one of the it's overall outcomes (*Basin Plan 2012*, cl 5.02(2)(c)). The Basin Plan sets the amount of water that can be taken each year, leaving enough to support the ecosystems that depend on it through environmental flows (MDBA 2024). Environmental flows are designed to support water-dependent ecosystems, by mimicking components of the natural flow regime. While environmental flows have increased longitudinal connectivity in the Murray Darling Basin (MDBA, 2018), flow constraints have limited the ability of environmental water managers and river operators to deliver overbank flows and unlock the benefits these overbank flows provide the river system and its surrounds.

Constraints

Constraints refer to existing river operations and structures that limit the capacity to deliver environmental flows to floodplains and wetland ecosystems. These constraints exist to protect private and public assets, as well as existing land use. However, they also limit the outcomes that environmental water holders and managers can achieve from using environmental water, and by extension, increase the risk that Basin Plan objectives will not be achieved (DEECA, 2023). Identifying ways to 'relax' these constraints may assist to optimise the environmental outcomes from environmental water delivery. There is a parallel process to assess the social and economic impacts of relaxing constraints, though these projects are not discussed here.

The Murray-Darling Basin Authority's Constraints Management Strategy, released in 2013, sets out areas where physical or operational barriers impact environmental water delivery and limit environmental outcomes. Constraints projects can include changes to river operating practices and rules, and the installation of physical features such as crossings and bridges to mitigate the impacts of higher environmental flows on social and economic values. These measures are intended to provide water managers with more flexibility in environmental flow delivery.

The outcomes of relaxing constraints are uncertain, so within the broader implementation of the Basin Plan, the Victorian Government has initiated a suite of investigations to assess the likely impacts of various constraint management options. This paper focuses on the assessment of environmental benefits and risks.

Project setting

The Victorian Constraints Measures Program aimed to test the feasibility of achieving environmental benefits in the Murray and Goulburn Rivers through the relaxation of constraints relating to environmental flow delivery limits. To determine the potential outcomes from the proposed changes, environmental response modelling was used to inform assessment of the range of options and inform decision making for the programs next steps.

Methods

This investigation included a limited set of ecological themes that aligned with both the expected outcomes in the Basinwide Environmental Flow Strategy and the availability of existing environmental response models

(MDBA, 2020). The assessment was based on a modelling approach, with hydrological flow scenarios and floodplain inundation modelled by Hydrology and Risk Consulting (HARC, 2022) and the University of Melbourne (John et al 2022). The hydraulic models were then used as inputs to ecological response models for vegetation, native fish, waterbirds, and geomorphology. Further assessment of environmental responses were undertaken using Bayesian models developed by the University of Melbourne on in-stream vegetation, water quality, platypus, turtles, macroinvertebrates/ production and connectivity.

The environmental water requirements were drawn from previous studies, including the University of Melbourne (Horne et al. 2022) for the Goulburn River and the RRCP by the NSW Government and MDBA for the Murray River.

Flow Scenarios

The Victorian government used previous modelling of flow regimes in the Goulburn River to identify scenarios that align with the objectives of the VCMP. Multiple relaxation scenarios were run for each of the rivers, as shown in Table 1. A 'do-nothing' scenario was also considered in some of the results, providing a qualitative assessment of the current paths of river condition. This was used as a base case and comparison point for the feasibility for environmental benefits under relaxed constraints.

Table 1. Flow scenarios used in the VCMP feasibility assessment in the Goulburn River

Goulburn River scenarios	Mid Goulburn	Lower Goulburn	Murray River scenarios	Hume to Yarrawonga reach	Yarrawonga to Wakool Junction reach
Base case / M10L9.5	10,000	9,500	Base case/ Y15D25	25,000	15,000
Goulburn Scenario 1 / M10L17	10,000	17,000	Scenario 1 / Y25D25	25,000	25,000
Goulburn Scenario 2 / M10L21	10,000	21,000	Scenario 2 / Y30D30	30,000	30,000
Goulburn Scenario 3 / M12L21	12,000	21,000	Scenario 3/ Y40D40	40,000	40,000
Goulburn Scenario 4 / M14L25	14,000	25,000	Scenario 4 / Y45D40	40,000	45,000

Assessment approach

Using the outputs from the modelling conducted by HARC and University of Melbourne, each of the themes was assessed using the models summarized in This investigation sought to identify the environmental benefits and risks associated with each hydrologic scenario and demonstrate the applicability for using modelling of technical detail to inform decision making. The approach estimated the likely reach scale and system-wide environmental outcomes of relaxing constraints. The assessment methods used a bottom-up approach based on our understanding of the environmental water requirements of individual species and processes within these themes.

Table 2. Several of the key models were originally developed to support the NSW RRCP assessment. The Murray River modelling was originally conducted for the RRCP project, with the instream modelling (such as native fish response) directly informing this work, and the overbank results being either clipped to a Victorian extent (native vegetation which was clipped to NSW for the RRCP reporting) or recreated for the Victorian assessment. All the modelling and interpretation was then provided to the VCMP project by the teams that were part of the NSW RRCP project (see Table 2). This allowed efficiencies to be captured, and ensured best practice and consistency with similar work in NSW. It also allowed the results to be considered concurrently, particularly those with overbank flows and potentially impacting both states.

The Goulburn River assessment also included Bayesian ecological modelling developed by University of Melbourne. The Goulburn River assessment therefore comprised multiple lines of evidence.

This investigation sought to identify the environmental benefits and risks associated with each hydrologic scenario and demonstrate the applicability for using modelling of technical detail to inform decision making. The approach estimated the likely reach scale and system-wide environmental outcomes of relaxing constraints. The assessment methods used a bottom-up approach based on our understanding of the environmental water requirements of individual species and processes within these themes.

Table 2. Models used in the environmental assessment. Additional details on each model can be found at the associated citation.

Theme	Model Type	Model	Citation
Vegetation	State transition	La Trobe University	DPE 2022 McPhan et al, 2022
	Bayesian	University of Melbourne	John et al, 2022
	Inundation extents and vegetation area comparisons	Alluvium	Alluvium, 2022a
Fish	Population model	Arthur Rylah Institute	DPE 2022 Todd et al, 2022
	Bayesian	University of Melbourne	John et al, 2022
Waterbirds	Statistical	Brandis Bino	DPE 2022 Bino et al al, 2022
Geomorphology	Erosion potential index	Alluvium	Alluvium, 2022
	Bayesian	University of Melbourne	John et al, 2022
Instream Productivity/ Invertebrates	Bayesian	University of Melbourne	John et al, 2022
Floodplain fish	Bayesian	University of Melbourne	John et al, 2022
Connectivity	Assessment of hydrologic model results	HARC, Alluvium	HARC, 2022 Alluvium, 2022a
Water Quality	Qualitative assessment of model results		Alluvium, 2022a

Results

Overall results

Environmental condition was found to improve in direct proportion to the level of constraints relaxation, with the larger relaxation scenarios showing the greatest benefit. The benefits associated with these scenarios are related to the increases in inundation of floodplain ecosystems.

In contrast, the 'do nothing' scenario showed an ongoing decline in the ecological values of the rivers. Continuing the current limited floodplain inundation poses significant risk to instream communities, with floodplain vegetation such as black box woodland and river red gum communities placed at risk. Additionally, the focused delivery of flow to bank level should be expected to contribute to erosion issues, as the river energy is focused instream.

The lower relaxation scenarios have the capacity to slow this decline, though some risk to environmental condition would remain. Some of the elements of the system, such as native fish, would see improvement in all relaxation scenarios when compared to the base case. The outcomes of lower relaxation scenarios for floodplain vegetation were influenced by the impact of environmental flow deliveries on unregulated spills (overtopping of storages). Some red gum areas show benefits in the lower relaxation scenarios, however outer areas of red gum, such as black box, have reduced access to inundation. The outer areas only currently reached by unregulated spills may suffer in the lower scenarios as controlled delivery fails to reach them, while increasing airspace in the dams (capturing the flows that would otherwise overtop and inundate the larger area).

A summary of the results for each theme are shown Table 3 below.

Table 3 Summary of outcomes

Theme	Summary of outcomes of relaxing constraints, compared to base case	
	Goulburn River	**Murray River**
Hydrologic connectivity	Improved longitudinal connectivity with up to 9% increase in August flows at Shepparton. Up to 4% increase in flows in July and October. Changes in lateral connectivity assessed via themes below	No adverse impacts to longitudinal connectivity. Lateral connectivity assessed through the themes below.
Vegetation quality	Relaxation of constraint to low levels (less than 22,000ML/day) to provide some support to native vegetation but remain vulnerable. High relaxation will allow targeted vegetation to be held in good condition, though some sacrifice of fringe areas due to reduced spills. Significant improvements in black box and river red gum will require relaxation of constraints in both the mid and lower Goulburn	Both black box woodland and river red gum forests/woodlands were responsive to the relaxation of flow constraints. Broad benefits of constraint relaxation to higher flow scenarios were representative of greater areas of woody species in good condition and reduced areas in critical condition
Vegetation quantity	Increased inundation of semi-aquatic, terrestrial flood-adapted/semi-aquatic, and terrestrial flood-adapted ecological vegetation classes in the Mid Goulburn and Lower Goulburn River. Negligible inundation of terrestrial (not flood-adapted) vegetation.	Over 2,289 ha of additional vegetation (81% increase) inundated through relaxation of constraints compared to base case, including 1562 ha terrestrial flood-adapted vegetation (154% increase), and 447 ha terrestrial flood-adapted semi-aquatic vegetation (77% increase). A negligible (1ha) of terrestrial not flood-adapted vegetation inundated at the highest constraint relaxation scenario.
Production	Negative impacts on production (compared to base case) if constraints are relaxed below 22,000 ML/day. Increased production (compared to base case) above 22,000 ML/day, as floodplains are inundated.	Up to 2% increase in mean annual production
Water quality	Relaxation of constraints as proposed and assessed is unlikely to adversely impact on any water quality parameters in this reach	Relaxation of constraints as proposed and modelled is unlikely to adversely impact on any water quality parameters in this reach
Macroinv.	Benefits to macroinvertebrate biomass and diversity are predicted if constraints in Mid Goulburn are relaxed above 11,000 ML/day and Lower Goulburn constraints are relaxed above 21,000 ML/day	Not assessed.
Native fish	Benefits for equilibrium, periodic and opportunistic fish increase with progressive relaxation of constraints up to ~20,000 ML/day in the Lower Goulburn River and ~12,000 ML/day in the Mid Goulburn River. Sustained benefits above these flows. Benefits to large fish such as Murray Cod are limited, however floodplain specialists are expected to significantly benefit from relaxed constraints that enable proposed frequency of floodplain inundation.	Up to 39% increase in expected mean population of Golden Perch. No change to Murray Cod population size with relaxation of constraints. Floodplain specialists are expected to significantly benefit from relaxed constraints that enable the proposed frequency of floodplain inundation.
Waterbirds	Mixed outcomes are predicted for waterbirds.	Not assessed – significant waterbird sites in Murray River are located downstream of Yarrawonga.

Theme	Summary of outcomes of relaxing constraints, compared to base case: Goulburn River	Murray River
	Increased median probability of waterbird breeding (up to +5%), +12% overall probability of waterbird breeding with relaxation of constraints. Decreased chance of large breeding events by up to 11%, but an increased chance of small breeding events by 11%. Overall reduction of long-term breeding likelihood by 3% with relaxation of constraints. Declines in long-term average waterbird abundances with relaxation of constraints, particularly for Large Waders (13% decline in 90th percentile, increased 25th percentile by 14%)	
Geomorph.	Decreased erosion is predicted as constraints are relaxed in the Lower Goulburn. Relaxation of constraints at above 12,000 ML/day (creating overbank flows) in the Mid Goulburn is also expected to decrease erosion potential	Decreased erosion potential expected when constraints are relaxed to 30,000 ML/day and higher.

Potential Risks

Any flow change carries with it the risk of unexpected outcomes that may undermine environmental benefits or affect the use of water resources to support social or economic values.

Out of season delivery

There are risks to platypus and turtle populations, water quality, fish migration and recruitment and macroinvertebrate populations associated with delivery of over-bank flows during summer or breeding seasons. Bank full and overbank flows will also only be delivered in accordance with applicable seasonal watering plans which will ensure transparency within the region and across jurisdictions. (VEWH, 2022)

Carp

Carp are known to degrade river and wetland systems. The distribution and effects of carp vary widely, however, unregulated rivers have been found to have lower carp numbers (Gehrke, 1995, Harris, 2016, Stuart et al., 2021). The Commonwealth Environmental Water Holder also notes that seasonal delivery of environmental water can be used to preferentially benefit native species. Overall, there is a risk that constraint relaxation may benefit carp. This suggests that the constraints project should proceed with caution to improve benefits to native fish and minimize the risk of benefits to carp.

Invasive vegetation

A range of environmental factors interact to influence weeds within riparian and floodplain systems, including flow characteristics (timing, duration), climate (rainfall and temperature) and land management (urban, grazing). For amphibious or aquatic weed species, flow restoration is likely to reduce the area of available habitat. For terrestrial weeds (those that do not need flooding), relaxing constraints may increase areas of available habitat, however, the risk is likely to be more influenced by other factors (land-use, climate). Therefore, managing weeds in riparian ecosystems requires a holistic approach to restore ecosystem health and function of the riparian communities.

Riparian grazing

Riparian areas are vulnerable to grazing pressures as they are often fertile and provide easy access to drinking water. Grazing is one of the major causes of riparian degradation and has significant impacts on riparian function and biodiversity. The relaxation of constraints can provide benefits to the riparian ecosystems, but the ecological outcomes are also dependent on managing riparian zones and grazing pressure.

Boat wake

Boat wash is one of a range of anthropogenic mechanisms that contributes to fluvial scour – an erosion process in which riverbank erosion increases due to higher shear stress associated with boat wakes (Alluvium

2022). Engaging floodplains via overbank flows is predicted to decrease the risk of flow-based erosion as energy is transferred to a larger area. However, a residual erosion risk from boat wake will remain under relaxed constraints and potentially reduce the net benefit from constraints relaxation within the reach.

Summary

Of the five risks assessed, the risk of out of season allocations appears easiest to manage as it already aligns with environmental flow planning, while the other threats are already manifest within the system. While it is possible that relaxing constraints will increase these risks, this is expected to be outweighed by the benefits relaxing constraints can provide. As these threats are already present in the system, river managers will need to consider complementary measures to mitigate these threats to river health.

Discussion

The investigation found that relaxation of constraints will have widespread benefits for the values assessed. These benefits occur both within each reach of the rivers studied, but also cumulatively across the whole system, and increase proportionately to the level of constraint relaxation.

Results

Our investigation showed that relaxing constraints in the Goulburn River and Murray River benefits wetland and floodplain habitats. This starts with the benefits to floodplain vegetation which provides habitat and resources for biota, including waterbirds. Outcomes in the river channel were not as clear, in part due to uncertainties around the links between floodplain and wetland inundation, life cycles of river fauna and associated food webs. The investigation showed the benefits increased with progressive relaxation of constraints due, in part, to the larger areas of floodplain engaged and increases in the frequency of inundation.

Relaxing constraints will increase the proportion of water-dependent vegetation communities that can be held in good condition between dry spells. This keeps the vegetation communities out of the critical condition status (i.e., ‘near death’) and increases their likelihood of surviving extended dry periods. The areas kept in the better condition groups increased with constraints relaxation, with minimal disbenefit to vegetation vulnerable to flooding. This effect was proportional to the extent to which constraints were relaxed, scenarios with lower flow rates have vegetation that spent less time in good condition. The current management scenarios (base case) can be expected to lead to ongoing decline of the system’s vegetation.

The benefits to floodplain vegetation are linked to delivery in the winter and spring. This is important as later season delivery has the capacity to cause adverse effects through turtle and platypus nest inundation and water quality issues. This risk needs to be considered within the broader context of how these species have evolved and persisted in these systems, including the way they have adapted to late winter and spring events. The identification of the risk triggers and responses through ongoing research, monitoring and adaption of environmental water delivery programs is recommended, rather than using these risks as a basis to not proceed with the further development of relaxed constraints.

The outcomes of the hydrologic modelling made available for his assessment also suggest that environmental water will become increasingly important for river and wetland health. This increase in importance would come about with climate change resulting in a net reduction in the frequency of floodplain inundation arising from streamflow inputs from tributary streams.

The disbenefits noted in the results require further investigations, together with remaining unknowns arising from the investigations. These disbenefits do not, however, outweigh the substantial ecological benefits of constraint relaxation. The disbenefits and uncertainties identified with a constraints relaxation program should be areas for further investigation under an ongoing program of work aimed at securing and delivering relaxed constraints in the Goulburn and Murray River systems.

Overall approach

While a range of different modelling approaches were utilized to inform this investigation, each was built on the integration of our understanding of the role of flow regimes on the life history and condition of each of the themes. It was also informed by data collected through a range of intervention and condition monitoring programs, some of which pre-date the Basin Plan. As a consequence, the outputs of the models were broadly as expected from the changes in flows. While each of the environmental model outputs were important, the project provided synergies due to the linkages between the portfolio of models used. There were direct linkages in parts, with hydrological and inundation modelling acting as direct inputs to the environmental models and risk assessment.

Additional considerations

The Basin Plan seeks to optimise social, economic, cultural and environmental outcomes arising from the use of Basin water resources. Within this context, this environmental assessment is just one input to the final decisions on planning and implementing constraint relaxation. Considerations relating to community and landholder impacts, Traditional Owner guidance and the legislative, policy and regulatory impacts are also important factors in the progression of projects of this type.

Conceptual demonstration

Implementation of the Basin Plan objectives is taking place across multiple scales from relatively small environmental assets to the whole Basin. Relaxation of constraints will occur across multiple river valleys, so it was important that the environmental assessment was undertaken at river valley scale, rather than individual environmental assets. The use of environmental response modelling has been able to demonstrate the potential outcome of river and basin management changes.

The use of modelling in the Victorian Constraints Management Program, and similarly the Reconnecting River Country Project, has been able to help show the feasibility of the project to deliver positive outcomes for the ecosystems that the river supports.

As the volumes of data available increases, and the quality of the modelling continues to improve, environmental response modelling has the capacity to help river management and basin planning decisions to be made with higher and higher confidence. As decisions are more informed and the benefits become easier to demonstrate, these models can help achieve the best possible outcomes for the environments our rivers support.

Acknowledgments

The assessment of environmental benefits and risks conducted for feasibility stage of the Victorian Constraints Measures Program uses modelling and inputs from a range of expert inputs. The assessment covers three reaches over two river systems and builds on much of the work previously conducted for the NSW Reconnecting River Country Project and the University of Melbourne investigations into the Goulburn River.

The investigation makes use of these previous studies, but also synthesises work and input from various sources. In addition to the members of the Alluvium Group team (encompassing Alluvium Consulting Australia and EcoFutures), the inputs and expertise of the following groups are recognised and acknowledged:

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The work conducted for the NSW Reconnecting River County Project was particularly important for the completion of this study. The majority of the work completed for the Murray River has been either informed directly by the NSW project, or the modelling results cropped to a Victoria extent. Any information from that project has been drawn on and interpreted by the original authors of the work as listed above.

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