Goulburn Constraints Measure Business Case –

Phase 2 Investigations

Environment, Land, Water and Planning

Goulburn Broken Catchment Management Authority

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Executive summary

This business case investigates the feasibility of addressing operational constraints within the Goulburn catchment in Victoria. The lower Goulburn floodplain is one of seven key focus areas for physical constraints within the Murray-Darling Basin, identified in the Murray-Darling Basin Authority's Constraints Management Strategy. In October 2014, the Murray-Darling Basin Ministerial Council agreed that business cases for all seven key focus areas would be developed by 30 November 2015.

The business case draws on the outcomes of the Goulburn Constraints Measure feasibility investigations and assesses the potential impacts to private and public land and assets arising from increased flooding options and examines possible mitigation options and costs. It seeks to maximise the achievement of environmental outcomes while minimising the overall cost associated with higher flows.

Site description and values

The Goulburn River is 570 km long, flowing from the Great Dividing Range upstream of Woods Point to the River Murray east of Echuca. The business case applies to the 440 kilometre (km) section of Goulburn River extending from Lake Eildon at the upstream end, to its connection with the River Murray near Echuca.

The Goulburn River has been identified as a high priority waterway in the Goulburn Broken Waterway Strategy due to its significant environmental values (GBCMA 2015). The river and its associated floodplain and wetland habitats support intact river red gum forest, and numerous threatened species such as Murray cod, trout cod, Macquarie perch, squirrel glider, and eastern great egret.

The lower Goulburn floodplain covers some 13,000 ha alongside the river channel and contains the Lower Goulburn National Park as well as many important cultural heritage sites. The entire lower Goulburn floodplain has been listed in '*A Directory of Important Wetlands*' (GBCMA, 2015a).

Water resource development in the Goulburn Catchment underpins the region's economy and is vital for sustaining the region's urban centres. The river and its floodplain also support a variety of recreational activities such as camping, fishing and boating.

Changes to hydrology

Flow along the Goulburn River has been highly modified by two major features; Lake Eildon and Goulburn Weir. Lake Eildon has a large storage capacity of 3,334 GL. Water released from Lake Eildon is diverted for irrigation purposes and used to provide managed environmental flows. The lake supplies a significant proportion of the water used in the Goulburn Murray Irrigation District.

With such a large storage capacity, operation of Lake Eildon fully regulates downstream flows in all but wet years. DSE (2011) found that under current conditions, flow events from Murchison to Shepparton of between 25,000 and 55,000 ML/d:

- occur 20% to 30% less often compared to unregulated conditions
- are 50% to 70% shorter compared to their unregulated duration
- have a maximum period between events that is 2.5 to 3.5 times longer than in the unregulated condition.

The frequency of overbank flows is now less than what is needed to maintain the health of the lower Goulburn floodplain and river channel.

Current condition

The Goulburn River floodplain is a water dependent ecosystem that depends on flooding to sustain its values. Changing the seasonal flow pattern disrupts the natural cycles of feeding, growing and breeding for many plants and animals. Because of this, many native species associated with the Goulburn River have significantly declined.

The wider Goulburn River catchment now supports reduced diversity, abundance and range of many native fish species. Similarly, the floodplain now supports a less diverse plant structure, limiting shelter for a range of species such as breeding zones for frogs and yabbies and nesting platforms for waterbirds. Loss of water habitat reduces the opportunity for water bird breeding, and feeding areas for diving species such as cormorants.

Even under current regulated flow conditions, floods occur regularly within the Goulburn River system. Based on a long term average, smaller floods in the order of 25,000 ML/day occur six years in ten and much larger events (40,000 ML/day) occur around three years in ten. These natural events impact both public and private land and assets. Accordingly, the existing infrastructure on the floodplain (roads and bridges) has been designed to accommodate this.

Proposed changes

The Goulburn Constraints Measure aims to restore the frequency of small flood peaks in the Goulburn River, for a similar duration to that experienced under current conditions. A key aim of the project would be to reduce the time between these smaller flood events occurring, which has extended from less than three years between events under natural conditions to over seven years under current operation of the system.

The project could deliver target flows of 25,000 ML/day at Shepparton for four to five days duration, on an average of one to three times per decade. Flows of this magnitude may result in small overbank events around minor flood level for the Goulburn River at Shepparton and would predominantly occur during extended dry periods.

Due to the fast rate of recession of existing flow events at Shepparton, a higher peak flow of 30,000 ML/day may be used to achieve the desirable duration at the target flow rate. In some event years, multiple flow peaks may be delivered to achieve different ecological outcomes.

Operating strategy

In order to meet the flow target, the project has investigated reducing water harvesting at Goulburn Weir (to Waranga Basin) and releasing from Lake Eildon (if necessary) to top up unregulated flows in the Goulburn River (from tributary streams). Releases from Lake Eildon are proposed to be limited to target 10,000 ML/day in the Alexandra area, a minor increase from the current limit of 9,500 ML/day.

Together, these two mechanisms could be used to increase the frequency and duration of overbank flow events in the lower Goulburn. An important element of this business case is an allowance for a conservative approach to achieving the desired flow rates including:

- *Building increased flow management knowledge:* through the development of the necessary tools, operating procedures and organisational capacity needed to support the proposed operating strategy. This includes testing against natural flow events in the period leading up to planned operation.
- *Phased implementation of the operating strategy:* the actual release of water is planned to start in 2024/25 (after all mitigation measures are agreed and implemented) and commence at a low flow, progressively targeting higher flows over a few years as experience in

releasing and risk management is gained. Therefore, commissioning of flow management would be phased and may occur over at least 3 years. It would involve testing and monitoring the extent of associated public and private inundation and their associated mitigations.

Ecological benefits and outcomes

The project would flood almost 12,000 ha of the Goulburn floodplain. This includes almost all of the wetlands and a significant area of floodplain forest contained within the Lower Goulburn National Park. Hydrological analysis has shown the shortfall in the recommended frequency and duration of these flood events can be met using the proposed approach from this project.

The project would directly contribute to ecological objectives sought by the Basin Plan by improving watering outcomes for significant high value wetland and vegetation communities including 2,075 ha (74%) of wetlands and 7,700 ha (41%) of native vegetation on the lower Goulburn floodplain. Additional areas of wetland (approximately 800 ha) and floodplain vegetation (1,400 ha) would also be watered within the mid Goulburn reach.

More frequent watering would result in a healthier and more productive ecosystem both within the Goulburn River and its surrounding wetland and vegetation communities. This would contribute to more abundant and diverse native flora and fauna species including native fish, bird, reptiles and mammals.

The project would also contribute to improved ecological outcomes in the River Murray, notably recruitment of golden perch and dispersal of native aquatic plant seeds and propagules downstream, as well as by providing increased flows in the River Murray.

Social and recreational benefits are expected to accrue from the project, including improvement to nature based tourism opportunities which provides a source of revenue for the region.

Third party impacts and mitigation activities

Further understanding and managing potential third party impacts is a critical component of investigating the delivery of higher flows to the lower Goulburn floodplain. Achieving a target flow of 25,000 ML/day at Shepparton could result in short durations of overbank flows, resulting in the flooding of private and public land on the Goulburn River floodplain below Lake Eildon.

Flow management involving unregulated catchment streamflow involves uncertainty in predicting and managing flows. Hence a risk management buffer above the target and peak flows is proposed. While the operating strategy will always be designed to contain flow within a peak of 30,000 ML/day at Shepparton, the risk management buffer ensures that any project impacts to third parties are adequately compensated or mitigated in the event that an unforeseen event arises.

Accordingly, the project's third party impacts and mitigation activities have been investigated assuming risk management buffers of 15,000 ML/day in the Eildon to Yea reach, 35,000 ML/day in the Yea to Goulburn Weir reach, and 40,000 ML/day in the Goulburn Weir to River Murray reach.

Based on the flooded footprint of the risk management buffer, the project scope encompasses private land on the lower Goulburn (5,100 ha) and mid Goulburn (3,600 ha) floodplains. This includes an estimated 1,500 ha of remnant vegetation (on privately owned land in the lower Goulburn) that would be expected to improve in health as a result of the project.

The actual area of land expected to be affected by flooding would be significantly less, as the planned operating strategy is to contain flows within the proposed peak. For example, the extent of private land flooded in the lower Goulburn at the peak flow of 30,000 ML/day is estimated at 2,600 ha. Additionally, it is known the hydraulic model is currently overestimating flood extent in the mid Goulburn downstream of Seymour, therefore the inundation footprint is likely to be reduced as modelling accuracy is improved.

A large number of private landholders would be affected by the project, with an estimated 562 properties falling within the footprint of the risk management buffer. The bulk of land encompassed by the project is used for dryland broadacre crops and pasture, and forestry. All affected landholders and third parties would need to be actively engaged and fully supportive should the project proceed.

Some specialist businesses, tourism facilities and recreational areas would be affected which, unmitigated, can result in a loss of revenue, as well restrictions to access. Most public infrastructure has been designed to avoid or withstand higher flows than those targeted by the project. However, roads, bridges and bike paths are impacted in the lower Goulburn. No urban centres are directly affected by these flows.

A suite of activities to mitigate these flooding impacts is outlined by this business case given that mitigating activities need to address the effects of relaxing constraints and to ensure that communities are fully supportive of the proposal. A high level overview of the mitigating actions includes:

- agreements with public and private land owners/managers to enable flows over private land, provide access to levees and offset increased maintenance costs
- upgrade and refurbishment of the existing levee network (and flow control structures)
- upgrades to private infrastructure e.g. provision of access crossings and pump relocation
- upgrades to public infrastructure, such as improved culverts on public roads and drainage schemes.

A range of supporting activities has also been identified to reduce uncertainty in predicting tributary inflows and offset impacts to other floodplain users.

Project risks

Potential adverse environmental impacts and risks to project delivery have been evaluated using the AS/NZS ISO 31000:2009 framework. Potential mitigation activities were identified for each of the identified risks. Should the project proceed beyond the feasibility stage, the project must be well resourced from a project management and engagement perspective to manage potential risks.

Critically, the success of this project relies on a communications and engagement program that understands and appropriately deals with the issues of each of the large number of stakeholders directly affected by higher flows in the Goulburn River, as well as full support at all levels of government.

There is currently some level of concern and opposition to this project within the community as they seek to understand the effect on their livelihoods and liveability against the current levels of flooding they experience. The extent of this issue will become better understood as direct engagement commences with individually affected landholders. This risk would be closely monitored by a Project Control Board established to oversee the delivery of the project.

Eligibility and funding source

The Goulburn Constraints Measure Project is consistent with the Constraints Management Strategy (MDBA, 2013a) in that it relaxes a constraint on the capacity to deliver environmental water in one of the key focus areas of the strategy.

This project is not part of a 'pre-existing' Commonwealth funded project, and it has not already been approved for funding by another organisation, either in full or in part. Should this project go ahead, Victoria would be seeking 100 per cent of project funding from the Commonwealth.

Ongoing investigations

The investigations to date have defined the scope of the overall project. However, assuming the next steps are agreed to proceed, further work is required to develop the detail of the project. A range of further investigations are required to confirm the flow rates, frequency and duration, the inundation footprint, refine the proposed works package and reduce uncertainties in cost.

Additional work is also required to inform the operating strategy, including decision making and streamflow forecasting tools, to ensure the achievement of the target flows and the management of third party impacts within agreed parameters.

Costs and timelines

Project costs have been escalated using the Commonwealth methodology for cost escalation. The total estimated capital cost of this project is $140.12 million and it is expected to be fully operational by 1 July 2024. A phased implementation of the operating strategy would occur beyond should the project proceed.

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Glossary and acronyms

BoM – Bureau of Meteorology

CAMBA -China Australia Migratory Bird Agreement

CEWO – Commonwealth Environmental Water Office

CMA - Catchment Management Authority

CMP - Constraints Management Project

CMS - Constraints Management Strategy

Cwlth - Commonwealth

DELWP - Department of Environment, Land, Water and Planning (Victoria)

DEPI - Department of Environment and Primary Industries (now DELWP)

DSE - Department of Sustainability and Environment (now DELWP)

EPBC Act - Environmental Protection and Biodiversity Conservation Act 1999

EVC - Ecological Vegetation Class

FFG Act - Flora and Fauna Guarantee Act 1988

GBCMA – Goulburn Broken Catchment Management Authority

GIS - Geographic Information System

GL - Gigalitres

GMW - Goulburn-Murray Water

GST - Goods and Services Tax

Guidelines - Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases

ha- Hectare(s)

IGA - Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin

IGA Protocol - Schedule 1 to the IGA (Protocol for consideration of surface water Sustainable Diversion Limit (SDL) adjustment measures)

IVT – Inter-Valley Transfer

JAMBA - Japan Australia Migratory Bird Agreement

km - Kilometre(s)

m – metres

MDBA - Murray-Darling Basin Authority

ML - Megalitres

mm/yr - Millimetres per year

NPV - Net Present Value

NSW – New South Wales

OH&S - Occupational Health and Safety

PCB - Project Control Board

R - river

RGG - Regulatory Governance Group

SDL – Sustainable Diversion Limit

The Basin Plan - The Murray-Darling Basin Plan adopted by the Commonwealth Minister under section 44 of the *Water Act 2007* (Cth) on 22 November 2012

VEWH – Victorian Environmental Water Holder

1. Introduction

1.1 Purpose

The business case defines the proposal for relieving constraints on the Goulburn River, one which aims to maximise the achievement of environmental outcomes while minimising the overall cost associated with higher flows.

It draws on the outcomes of the Goulburn Constraints Measure feasibility investigations and assesses the potential impacts to private and public land and assets arising from increased flooding options and examines possible mitigation options and costs, should the project proceed.

The business case applies to the 440 kilometre section of Goulburn River extending from Lake Eildon at the upstream end, to its connection with the River Murray near Echuca.

1.2 Context

The Constraints Management Strategy (MDBA, 2013a) identified seven priority areas (key focus areas) for addressing physical constraints in the Murray Darling Basin. The Goulburn River was identified as one of these focus areas where relaxing constraints is important for achieving both Basin-scale and local outcomes.

In response to this, the Commonwealth Government has provided funding to the Victorian state government to develop this Business Case to investigate relieving constraints to higher flows along the Goulburn River in order to:

i. understand issues and benefits associated with higher flows, and
ii. determine what mitigation options are needed.

Any decisions to remove or relax constraints would be made by mutual agreement of all Basin governments by 30 June 2016 in accordance with the process set out in the 2013 Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin (the IGA). Agreed constraints projects are intended to be operational by 2024.

In 2014 Basin Ministers agreed to develop business cases for each of the seven key focus areas identified in the Constraints Management Strategy. This business case has been prepared by the government of Victoria in response to that decision and focuses on the Goulburn River key focus area.

The IGA sets out three phases for the evaluation of supply and constraint measures: feasibility studies (Phase 1), business cases (Phase 2), and confirmation of projects (Phase 3).

This business case is written in accordance with the Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases (MDBA, 2014c) which sets out what is expected of proponent jurisdictions in developing business cases (including standards, information requirements and minimum specifications).

1.3 Brief history of the development of this business case

This business case draws on work undertaken over many years to understand the ecology of the Goulburn River, the flows required to maintain a healthy system and the works needed to deliver these requirements. The investigations have been supported by on-ground knowledge gained from environmental water delivered through this period, the natural flooding of 2010-11 and consultation with local communities and land managers.

During the development of the business case, a range of investigations have occurred to better understand constraints in the Goulburn River system, including modelling of flood extents and tributary inflows to inform the assessments of third party impacts. Importantly, these findings are being further substantiated through ongoing consultation with the affected community, agencies and businesses. This process would continue beyond the life of this business case.

As a result, the proposal for the Goulburn River is now better defined and the uncertainty regarding potential impacts and estimated costs has been reduced. Combined with the other business cases for proposed constraint measures in the mid and lower River Murray, this business case proposes new ways to improve the outcomes from environmental water delivery, while avoiding or mitigating the impacts on local communities.

The supporting investigations for this business case have been overseen by a steering committee from key stakeholder agencies. The business case was delivered as a partnership between the Goulburn Broken Catchment Management Authority (GBCMA), the Department of Environment, Land, Water and Planning (DELWP) and the Murray Darling Basin Authority (MDBA).

Investigations undertaken to date are fit for meeting the requirements of the business case, with recognition that a range of work needs to continue prior to the project proceeding to implementation.

The key activities prior to the development of this business case are presented in Figure 1.

A summary of the key investigations and studies that have informed the development of this business case is presented as Appendix 1.

2003 Investigations into the environmental water requirements of the Goulburn River commence, leading to an initial set of flow recommendations that includes overbank flows.

2004 Environmental water deliveries to wetlands on the Goulburn River floodplain commence including sites such as Gemmill Swamp and Reedy Wildlife Reserve.

2006 Investigations into the constraints to delivering water across major streams in northern Victoria is commissioned and identifies third party flood impacts as an issue for the Goulburn River that require further consideration.

2007 Further environmental flow investigations occur to better understand trade-offs between water delivered for environmental and consumptive use, including the effects of inter-valley transfers on summer flows in the Goulburn River.

2010 Hydraulic Model of the Goulburn River and its floodplain is developed to improve understanding of relationship between flow rates and flooding impacts. Natural flooding occurs during spring 2010 and summer 2011.

2011 Additional work is undertaken to refine the recommendations for overbank flow events, focussing on the needs of water dependant flora and fauna. Key flow targets of 25,000 ML/d and 40,000 ML/d are identified. Within river environmental flow deliveries commence.

2012 Basin Plan is released which sets sustainable limits for the amount of water (surface and groundwater) that can be extracted from the Murray-Darling Basin and identifies specific floodplain watering objectives for the lower Goulburn floodplain (below Goulburn Weir) that include overbank flows.

2013 Constraints Management Strategy is released which aims to identify ways of relaxing or removing constraints to environmental water delivery to maximise ecological outcomes. Goulburn River is identified as a key focus area by this strategy.

2014 Goulburn Constraints Management project commences Phase 1 investigations to understand the issues involved in lower Goulburn floodplain watering, the works needed to mitigate those issues and estimate the costs of achieving those outcomes. Findings documented in the MDBA Constraints Management Strategy annual progress report 2013-14.

2015 Commonwealth funding is released to the State of Victoria and Goulburn Broken CMA is engaged to deliver the Business case (Phase 2) investigations.

Figure 1: Key activities and investigations prior to the development of this business case

1.4 Project area

The Goulburn River key focus area encompasses the mid and lower sections of the Goulburn River. The mid Goulburn section extends from Lake Eildon to Goulburn Weir, and the lower Goulburn section extends from Goulburn Weir to its connection with the River Murray near Echuca (Figure 2). The upper Goulburn (above Lake Eildon) is unregulated and is not managed for environmental flows and therefore falls outside the focus area.

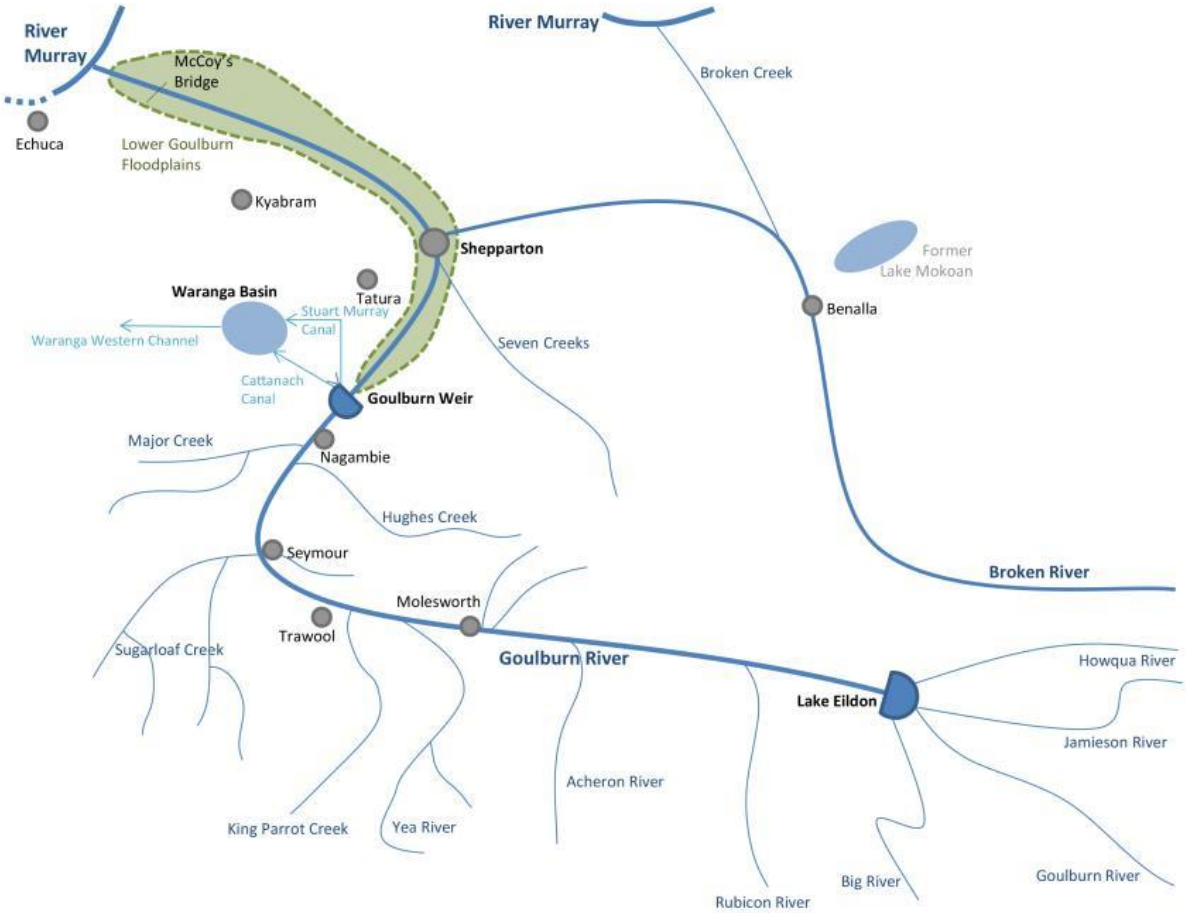

Figure 2: The Goulburn River key focus area, showing key tributaries and features (Source: MDBA, 2015)

The Basin Plan has specific floodplain watering objectives for the lower Goulburn floodplain (section 1.6), however water needs to first pass through the mid Goulburn system in order to achieve the higher flows needed to meet those objectives.

1.5 Catchment overview

The Goulburn River Basin is Victoria's largest covering 1.6 million hectares or 7.1 per cent of Victoria (GBCMA, 2014). It has a mean annual discharge of approximately 3,040 GL representing 13.7 per cent of the total state discharge (GBCMA, 2015b) and 11% of the total annual flows to the Murray-Darling Basin (MDBA, 2014b).

The Goulburn River is 570 km long and runs in a north-easterly direction, flowing from the Great Dividing Range upstream of Woods Point to the River Murray east of Echuca. The river flows through major towns such as Seymour, Nagambie and Shepparton (Figure 3).

Figure 3: Overview of the Goulburn Broken catchment

Between Eildon and Seymour the river flows through narrow floodplains, surrounded by hills. The river has a limited capacity in the Molesworth region, providing a natural restriction to higher managed flows through this section. Due to the steepness of the surrounding topography, rainfall can cause rapid flow increases in tributary streams, resulting in flashy flows that can affect riverbank farmers and communities, including the township of Seymour.

Below Seymour the catchment flattens out and the river is joined by large tributaries of Seven Creeks and the Broken River near Shepparton, which drain 25% of the total Goulburn Broken catchment area. Downstream of Shepparton, the river naturally breaks out and floods wide areas, particularly to the north of the river towards Deep Creek. Levee systems now exist along much of this length of the river to limit the extent of inundation in low to moderate floods.

The Goulburn River has been developed to capture water for consumptive use, particularly irrigation on the plains of northern Victoria. The Lake Eildon storage in the headwaters and Goulburn Weir (which supplies the Waranga Basin) in the middle of the catchment harvest flows in the river, capturing minor and moderate floods and disconnecting the river from its floodplain.

The current regulated operation of the river system provides flows within a range that is largely governed by irrigation requirements, minimum flow provisions and operational constraints. Releases from storages resulting in overbank flows are a consequence of managing storages when they are close to full or spilling over, rather than to meet environmental objectives. As a result, the flows in the lower Goulburn have significantly changed from natural flow conditions.

Water resource development in the Goulburn Catchment underpins the region's economy and is vital for sustaining the region's urban centres. The Shepparton Irrigation Region alone creates agricultural products worth an estimated $1.38 billion per annum and supports an estimated 30% of jobs in the catchment's economy (Monticello, 2012).

Primary industries dispersed across the Goulburn River floodplain include dairy, horticulture, viticulture, livestock production (beef, sheep, goats, pigs and poultry), cropping, timber production and aquaculture. Smaller enterprises include horse breeding, nurseries, mushrooms, turf and cutflower production. Land use increasingly supports lifestyle living, particularly towards the south of the catchment closer to Melbourne.

The river is also valued by the broader community for its high recreational and aesthetic values, such as camping, fishing, bushwalking, kayaking and birdwatching, as well as a source of firewood for heating homes. A well-patronised and high quality recreational trout fishery exists between Lake Eildon and Yea, and contributes to approximately 25% of anglers catch (Cottingham et. al., 2014b). Nature based tourism is cited as the most common reason for visiting the Goulburn River valley (Ruzzene, 2014) and, combined with cultural heritage tourism, are also important employers (Montecillo 2012) particularly for bush-based tourism opportunities below Goulburn Weir.

The Traditional Owners of the Goulburn Catchment have an intrinsic connection to the land and water resources within the landscape. The Traditional Owners in the north of the catchment are the Yorta Yorta Nation, whose traditional lands include the northern plains of the Goulburn and Murray Rivers. The south of the catchment forms part of the traditional lands of Taungurung Clans, which includes the mountains and rivers to the Great Divide.

Proposed changes to the management of the region's water resources through the Goulburn Constraints Measure are therefore of interest and concern to a broad range of stakeholders.

1.6 Rationale for the project

The Goulburn River and its associated floodplain and wetland habitats support intact river red gum forest, numerous threatened fish, mammal and bird species. The lower Goulburn floodplain covers some 13,000 ha alongside the river channel and contains the Lower Goulburn National Park as well as many important cultural heritage sites.

The river underpins the region's economy, being a major source of water for irrigated food production. The associated water harvesting from the river has substantially altered the river's flow regime in the lower Goulburn, particularly reducing the frequency and duration of overbank flows. In addition, economic development over many years has resulted in significant economic and social use of the floodplain.

The Goulburn River is now highly regulated and flow is largely governed by irrigation requirements and minimum flow provisions. It is operated to maximise water availability for consumptive use and to limit evaporative losses. This constrains the occurrence of bank-full or overbank flows that connect the river and its floodplain and sustain the health of the river system. Changes to the seasonal flow pattern has disrupted the natural cycles of feeding, growing and breeding for many plants and animals. Because of this, many native species associated with the Goulburn River have significantly declined. A series of studies have consistently reported that the reduced frequency and duration of overbank flows has adversely impacted the health of the lower Goulburn floodplain and river channel (Cottingham, 2011; DEPI, 2013; Cottingham et al., 2014; GBCMA, 2015).

In summary, key changes in ecological condition include:

- reduced fish diversity and abundance
- reduced extent of riparian zone due to land clearing and encroachment by agriculture
- reduced overbank flows changing the nature of carbon inputs that support river and wetland food webs
- loss of fish habitat and reduced bed diversity resulting from previous desnagging activities and the removal of source material from the riparian zone
- high incidence of exotic plant species in the riparian and wetland areas
- reduced opportunity for widespread waterbird breeding events.

The Goulburn Constraints Measure aims to contribute to the environmental objectives of the Basin Plan, being:

i. To protect and restore water-dependent ecosystems that support migratory birds listed under international agreements
ii. To protect and restore water-dependent ecosystems that provide vital habitat
iii. To protect and restore water-dependent ecosystems that support Commonwealth or state listed threatened species and/or ecological communities.

Floodplain inundation is necessary to achieve these objectives. In the Goulburn, this will require addressing physical constraints on the delivery of high flows (section 7).

2. Project Details

2.1 Description of the measure

The Goulburn Constraints Measure ('the project') is aiming to water the lower Goulburn floodplain, to fill wetlands and water the forested areas within the existing levee system.

The objectives of the project are:

i. Increase the frequency and duration of lower Goulburn floodplain inundation during winter and spring to improve the health and condition of ecological values
ii. To better connect the floodplain with the river, and
iii. In conjunction with the other constraint projects within the basin, improve floodplain inundation along the length of the Murray to the Coorong.

Relaxing constraints in the Goulburn would provide improve the ability to deliver higher flows to the lower Goulburn floodplain. This will provide significant local environmental benefits and also help to increase flows in the River Murray, providing benefits to downstream floodplain areas.

Flow rates

The Goulburn Constraints Measure has defined target and peak flow rates at Shepparton (below Goulburn Weir) to achieve the project's intended environmental benefits (Table 2-1).

Risk management buffers have also been developed to consider potential third party risks, should higher than anticipated flows occur.

The proposed target flow rate is 25,000 ML/day for four to five days, one to three times per decade, on average (section 6.30). In some event years, multiple flow peaks may be delivered to achieve different ecological outcomes (Table 6-3). The target flow was informed by a range of investigations undertaken during the feasibility stage (Appendix 1). While it is at the lower end of the overbank flow recommendations for the lower Goulburn system (DSE, 2011), the target flow considers both ecological objectives and potential third party impacts (section 8).

To achieve ecologicial objectives, a higher peak flow (up to 30,000 ML/day) may need to be delivered to achieve the desired duration (four to five days), due to the fast rate of recession of flows at Shepparton.

Table 2-1: Summary of proposed flow rates at Shepparton (downstream of Goulburn Weir)

Current or proposed flow	Flow rate at Shepparton
Current	8,500 ML/day
Target flow	25,000 ML/day
Peak flow	30,000 ML/day
Risk management buffer	40,000 ML/day

Due to uncertainty in predicting tributary inflows, risk management buffers are proposed to ensure the project has planned and accounted for potential third party risks if higher than anticipated flows occur. The risk management buffers identified by the project (from upstream to downstream) include:

- 10,000 ML/day at the Lake Eildon outlet
- 15,000 ML/day at Alexandra
- 35,000 ML/day at Seymour
- 40,000 ML/day at Shepparton.

For the purposes of this business case, the target flow of 25,000 ML/day is used to describe the potential ecological outcomes of the project and the risk management buffer (40,000 ML/day) is used to determine the project's impacts and mitigation options.

A summary of the key terms used to describe the operating strategy and project impacts is provided in Figure 4 below.

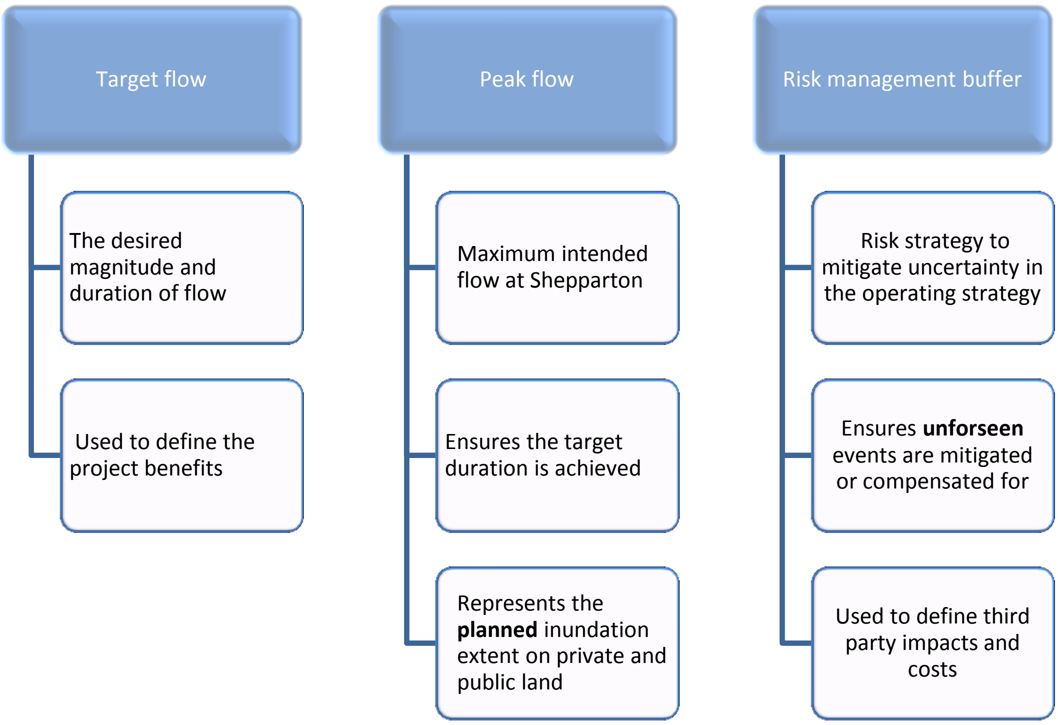

Figure 4: Summary of key terms used to describe the project benefits and impacts

Delivery method

In order to meet the flow target, the project proposes to reduce water harvesting at Goulburn Weir (to Waranga Basin) and increase releases from Lake Eildon to top up unregulated flow events in the Goulburn River.

The storage operator, Goulburn-Murray Water (GMW), normally harvests up to 7,200 ML/day from unregulated flow events at Goulburn Weir over the winter/spring months to fill Waranga Basin. When Waranga Basin is full, harvesting ceases. Reducing or ceasing diversions during targeted events could allow unregulated flows to pass downstream, increasing the flow peak passing through the lower Goulburn. Any shortfall in harvesting to Waranga that ultimately arises during the water year would need to be debited from environmental water accounts to ensure no loss of resource to entitlement holders.

Releases from Lake Eildon are currently restricted to a maximum of 9,500 ML/d (measured at Alexandra) to avoid creating localised flooding downstream at Molesworth. Releases are reduced or ceased when there are significant flows in downstream tributaries, particularly the Acheron or Rubicon Rivers. Raising this flow limit to a target flow of 10,000 ML/d, with a buffer of up to 15,000 ML/day, could allow releases from Lake Eildon to be made at the same time peak flows are observed in unregulated tributary streams (such as Acheron and Rubicon Rivers).

Together, these two mechanisms could be used to increase the frequency and duration of high flow events in the lower Goulburn. Decisions to ceasing harvesting to Waranga Basin would occur based on observed rainfall and measured flows at upstream gauging sites. Decisions to release from Lake Eildon would be made based on forecast rainfall and streamflow. As rainfall and streamflow occur, releases from Lake Eildon and diversions to Waranga Basin could be adjusted to provide the required flows and limit the risk of higher flows to within the risk management buffer.

A more detailed description of the delivery method is provided in section 7 of this business case.

2.2 Impacts and mitigation activities

Hydraulic modelling has been carried out to better understand the relationship between additional environmental benefit (section 4.2) and increased risk to private and public land and assets (section 8.3) as flows increase. This has been supported by a range of technical investigations to build knowledge on the suitability of the existing levee system, along with potential impacts on public infrastructure, and private agricultural and specialist businesses (Appendix 1).

A target flow of 25,000 ML/day at Shepparton results in significant areas of flooding within the intended vegetation communities. An estimated 12,000 ha is expected to be inundated, including 74% of all the wetland area and 50% of native vegetation downstream of Lake Eildon (section 4.2). A summary of the anticipated ecological outcomes from this inundation is provided in section 4 of this business case. A detailed discussion on third party impacts is provided in section 8. The associated third party impacts include:

- 5,100 ha inundation of private land on the lower Goulburn floodplain at the 40,000 ML/day risk management buffer set for Shepparton.
- 3,600 ha inundation of private land in the mid Goulburn, based on risk management buffers of 15,000 ML/day and 35,000 ML/day for Alexandra and Seymour, respectively.

Across the project area, the area of private land inundated increases steadily with increasing flow. The bulk of this land is used for dryland broadacre crops and pasture, and forestry. Some caravan parks and recreational areas are also affected. Inundation can result in a loss of productivity for agriculture, as well restrictions to access.

The lower Goulburn floodplain downstream of Shepparton is largely contained within a network of levees (Figure 21). These levees limit the ultimate extent of inundation from overbank flows of the magnitude proposed. The levee system also increases the proportion of overbank flow which continues along the Goulburn River.

As floods of this magnitude already occur in the mid and lower Goulburn, most public infrastructure has been designed to avoid or withstand higher flows than those proposed by the project. However, roads, some bridges and some bike paths would be impacted in the lower Goulburn. No urban centres are directly affected by these flows.

The proposed works associated with this business case aim to mitigate these flooding impacts and include:

- agreements with landholders to allow flows over private land
- refurbishment of parts of the existing lower Goulburn levee system to ensure it prevents flooding outside the levees
- upgrades to private infrastructure, such as improved creek crossings on private land
- upgrades to public infrastructure, such as improved culverts on public roads and drainage schemes
- agreements with public land or asset managers to offset increased maintenance costs as a result of more frequent higher flows
- agreements with operators of affected businesses (e.g. caravan parks) to mitigate impacts of higher flows
- improvements to the existing streamflow and rainfall measurement network to manage the risk that flows may be higher than intended
- effective decision support tools would be developed that assist with the prediction of tributary inflows and inform operating rules
- a phased introduction of flow releases to test and develop operating practices and to allow ground-truthing of expected inundation
- provision for adequate buffers to ensure that flooding does not occur outside planned areas if tributary inflows are greater than predicted.

Further details on the mitigation options for managing third party risks are presented in section 9. As the Goulburn Constraints Measure is at the feasibility stage, further work to confirm third party impacts and refine the mitigation activities will be required if the project proceeds.

A high level risk assessment has been completed and has found that most third party impacts could be managed within acceptable levels with appropriate mitigation actions in place (section 8). There is, however, community resistance to agreements that allow flooding over private land (section 12.5) which poses a key risk to the project timeframes and delivery.

2.3 Costs and proposed schedule

The total estimated capital cost of this project is $140.12 million. All capital costs to implement the proposal have been scheduled across the eight year implementation period. Indexation has been applied to these costs, which are shown in nominal dollars.

The ongoing annual operation and maintenance costs are estimated at $1.1 million in present value dollars.

The proposed project schedule is presented in

Table 2-2 and shows that the works are expected to be fully operational by June 2024, satisfying the requirements of clause 7.12(4)(d) of the Basin Plan and Table 1 of the IGA Protocol (MDBA, 2014c).

2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/36	20
ion and detailed design									
ection & consultation		Negotiation of easements and construction							
							Commissioning & phased impleme the operation s		

There is however a significant risk that putting agreements in place could take longer than the five years allowed, as discussed in section 14.2.

A detailed breakdown of the proposed schedule is provided in section 14.3.

Table 2-2: Proposed schedule

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/36	2026/27	Ongoing
Phase 1:	Investigation and detailed design											
Phase 2:	Data collection & consultation			Negotiation of easements and construction					↔			
Phase 3:									Commissioning & phased implementation the operation strategy			↔

2.4 Name of the proponent and proposed implementing entity

As the project owner, DELWP would have oversight responsibility for project implementation, pending confirmation of funding. Further information regarding the proposed governance and project management arrangements for implementation is provided in section 14.

2.5 Sustainable Diversion Limits resource units affected

The project results in activity within the Goulburn Sustainable Diversion Limit resource unit (SS6).

The project also results in benefits in the Victorian Murray (SS2) and New South Wales Murray (SS14) however these are not considered in detail by this business case.

2.6 Eligibility for Commonwealth funding

As noted in the introductory section, any decision to proceed with this proposal would be done in consultation with affected communities, noting the broader intergovernmental process to finalise a full adjustment package by 30 June 2016. The final decision that is made would determine the Commonwealth funding source that would be accessed to implement the project.

Victoria confirms this is a new project, additional to those already included in the benchmark assumptions under the Basin Plan. Pending a final decision to proceed with this project, its operation is expected to:

- remove or ease a physical or other constraint on the capacity to deliver environmental water to the environmental assets of the Murray-Darling Basin
- allow environmental water to be used to a greater effect (if incorporated into the final adjustment package), and
- be designed, implemented and operational within agreed timeframes.

This project is not part of a 'pre-existing' Commonwealth funded project, and it has not already been approved for funding by another organisation, either in full or in part.

2.7 Confirmation that the measure is consistent with the CMS

The Goulburn Constraints Measure is consistent with the Constraints Management Strategy (MDBA, 2013a) in that it relaxes a constraint on the capacity to deliver environmental water in one of the key focus areas of the strategy.

The measure is consistent with the key principles of the strategy in that it:

- aims to maximise environmental outcomes that can be obtained from managing environmental water (and managing water for other purposes on route).
- considers and mitigates the impact on affected parties e.g. land holders, water entitlement holders, Traditional Owners, management agencies and local government
- identifies solutions that use the approach outlined by the strategy and fall within the boundaries defined by the Commonwealth Water Act (2007), the Basin Plan and relevant state water access and planning schemes
- allows all water holders to use their water efficiently to meet the needs of that use, while not adversely affecting other entitlements
- confirms the proposed measure with relevant Basin governments and relevant stakeholders to resolve issues before changes to on-ground arrangements are made.
- informs the decision making of government and recommends investment that is:

- prioritised on optimising Basin-wide environmental outcomes, taking into account economic and social considerations
- focussed on solutions that provide long term certainty and protection to stakeholders
- focussed on avoiding and addressing any impacts to third parties.

2.8 Summary of options considered

A multi-criteria analysis was carried out to compare how variations to the target flow, peak flow and risk management buffer influence the ecological outcomes, as well as the cost of offsetting impacts to third parties. The analysis considered a range of target flows up to 40,000 ML/day at Shepparton. Target flows above 40,000 ML/day were not considered due to the low incremental benefit of delivering flows above this rate and the accelerating mitigation costs and risks, particularly associated with the lower Goulburn levee system.

The criteria used were:

- ability to achieve ecological objectives (area of wetlands and forests inundated)
- extent of potential impacts (area of private land flooded, number of buildings affected, number of titles affected)
- cost to implement (including both works to enable flooding and mitigation actions).

The results are presented in Table 2-3, which summarises the outcomes of technical investigations undertaken during the feasibility stage (Appendix 1). Options 1 and 2 considered the effect of different peak flows at Shepparton on the project impacts and benefits (30,000 ML/day versus 40,000 ML/day). Options A and B looked at the sensitivity of these results to the risk management buffer at Alexandra (15,000 ML/day versus 20,000 ML/day).

Table 2-3 shows that while the inundation footprints for wetlands and native vegetation progressively increase with increasing flow rates, there is a corresponding increase in the area of private land flooded, buildings inundated and titles affected. Similarly, the cost of offsetting these third party impacts also increases significantly. This has been a key decision point for the project.

The initial option proposed by the Constraints Management Strategy (MDBA, 2013a) targeted 40,000 ML/day at Shepparton and 15,000 ML/day at Alexandra (option 2B). Private land comprises almost 40% of the inundation footprint for Option 2B, with a mitigation cost of $193.15 million.

For other options investigated, the majority (79%) of flooding in the lower Goulburn floodplain occurs on public land up to the peak flow rate of 30,000 ML/d at Shepparton. Above these flow rates, an increasing proportion of the additional area flooded occurs on privately owned land. This has been a further key decision point for the project.

Consideration of project costs and inundation of private land were also balanced against feedback provided through community consultation activities (section 12.5). In particular, feedback indicated strong community concerns regarding peak flows of 40,000 ML/day at Shepparton (options 2A and 2B) and a risk management buffer of 15,000 ML/day at Alexandra (options 1B and 2B).

In view of the step change in project impacts and costs and the increased community concern associated with achieving higher flow rates, option 1A was selected as the preferred option as it meets the project’s intended ecological outcomes, while minimizing the additional scale and cost of mitigation actions for third party impacts.

Under a ‘do nothing’ or current scenario, floods in the order of 25,000 ML/day occur on average six years in ten (DSE, 2011). The proposed operating strategy for Option 1A aims to increase flood frequency to an average of eight years in ten (Table 6-2). While an additional two events per decade would have material impacts on people and businesses, the target flow proposed is one that is commonly experienced by the community.

Table 2-3: Selection of the preferred option

	Category		Option 1A	Option 1B	Option 2A	Option 2B
Flow (ML/day)	Shepparton target flow		25,000	25,000	35,000	35,000
	Shepparton peak flow		30,000	30,000	40,000	40,000
	Shepparton risk buffer		40,000	40,000	55,000	55,000
	Alexandra flow limit		10,000	15,000	10,000	15,000
	Alexandra risk buffer		15,000	20,000	15,000	20,000
Inundation	Lower Goulburn	Wetlands	2,075 ha	2,075 ha	2,740 ha	2,740 ha
		Vegetation	7,700 ha	7,700 ha	12,130 ha	12,130 ha
	Mid Goulburn	Wetlands	<800 ha	<900 ha	<850 ha	<1,000 ha
		Forests	<1,400 ha	<1,750 ha	<2,500 ha	<2,800 ha
	Private land	Lower Goulburn	5,120 ha	5,120 ha	8,780 ha	8,780 ha
		Mid Goulburn[1]	3,210 ha	3,969 ha	4,173 ha	4,934 ha
	Buildings	Lower Goulburn	13	13	62	62
		Mid Goulburn[2]	12	18	22	28
	Titles	Lower Goulburn	257	257	409	409
		Mid Goulburn	305	325[3]	305	325[3]
		Cost	$140.12 m	$160.45 m	$174.15m	$193.15 m

[1] Estimated extent for each option calculated using sum of inundation at the risk buffer at Alexandra for Eildon to Yea and inundation at the Shepparton peak flow for downstream of Yea to the Goulburn Weir
[2] As above but for buildings
[3] Based on a risk management buffer of 17,500 ML/day at Alexandra therefore the actual number of titles is expected to be greater

3. Environmental values

The Goulburn River has been identified as a high priority waterway in the Goulburn Broken Waterway Strategy 2014 – 2022 due to its significant environmental values (GBCMA 2015). The river and its associated floodplain and wetland habitats consists of a diversity of vegetation and large areas of habitat for fauna such as waterbirds and fish. It is considered an excellent example of a major floodplain system (Cottingham & SKM, 2011).

3.1 Floodplain values

The Goulburn River spans the Murray Fans and Victorian Riverina bioregions, two of three bioregions along the River Murray floodplain downstream of the Ovens junction (VEAC, 2008). The Goulburn River maintains ecological diversity by supporting vegetation communities representative of these bioregions.

The Goulburn River floodplain contains twenty five flood dependent vegetation communities, representing a diverse range of floristic composition and ecological processes. Twenty four of these are of conservation significance under the Victorian classification system, including fourteen vegetation communities classified as endangered. The riparian zone is dominated by Floodplain Riparian Woodland and is characterised by a canopy layer of river red gum (*Eucaplyptus camaldulensis*) and yellow box (*Eucalyptus melliodora*).

Flood dependent Ecological Vegetation Classes (EVCs) on the Goulburn River floodplain are presented in Appendix 2.

The lower Goulburn River and floodplain provide a variety of key habitats including a network of 'flood runners' and wetlands (both permanent and ephemeral). The entire lower Goulburn floodplain has been listed in '*A Directory of Important Wetlands*' (GBCMA, 2015a) and is known to contain eleven different wetland vegetation communities. These ecosystems support important species and habitats that are listed in international and national agreements (GBCMA, 2015a).

A total of five listed plant species have been recorded on the Goulburn floodplain, including two species listed under the *EPBC Act* (1999): river swamp wallaby-grass (*Amphibromus fluitans*) (Figure 5) and small scurf pea (*Cullen parvum*).

The Goulburn River floodplain provides habitat for a range of amphibian and reptile species, including state listed species such as the vulnerable lace goanna (*Varanus varius*) and the endangered brown toadlet (*Pseudophryne bibronii*). the yellow-footed antechinus (*Antechinus flavipes*) and the platypus (*Ornithorhynchus anatinu*) are found in the catchment in low abundances due to a loss of suitable habitat.

Listed flora and fauna species recorded on the Goulburn River floodplain are presented in Appendix 3.

Figure 5: River swamp wallaby-grass, a nationally endangered species found on the Goulburn River floodplain (Photo: D. Cook)

Figure 6: Squirrel glider observed on the Goulburn River near Shepparton (Photo: K. Ward)

The forest vegetation supplies habitat to mammals such as the FFG-listed squirrel glider (*Petaurus norfolcensis*) (Figure 6) and brush-tailed phascogale (*Phascogale tapoatafa*). Other mammals such as the Yellow-footed antechinus (*Antechinus flavipes*) and the Platypus (*Ornithorhynchus anatinu*) are found in the catchment in low abundances due to a loss of suitable habitat.

3.2 Instream values

The aquatic environments of the Goulburn River floodplain and its associated floodplain provide valuable habitat for native fish species, including nine species listed under the *FFG Act* (1998) and/or the *EPBC Act* (1999). Recent surveys (Koster, 2012) have detected at total of thirteen native fish species in the lower Goulburn. This includes the nationally endangered trout cod (*Maccullochella macquariensis*), as well as the vulnerable Murray cod (*Maccullochella peelii peelii*). The nationally endangered Macquarie perch (*Macquaria australasica*) has been absent from lower Goulburn fish surveys, but still persists upstream of the Goulburn Weir.

A number of species of state significance also occur in the Goulburn River including the critically endangered silver perch (*Bidyanus bidyanus*), endangered freshwater catfish (*Tandanus tandanus*) and the vulnerable flat-headed galaxias (*Galaxias rostratus*).

The lower Goulburn River is important for fish spawning, particularly golden perch (*Macquaria ambigua*) (Figure 7), and its potential contribution to fish populations in the River Murray system.

A summary of the listed fish species and their conservation significance is presented in Appendix 3.

Figure 7: Golden perch eggs captured during Goulburn River larval drift sampling (Photo: W. Koster)

3.3 Birds

The Goulburn River floodplain supports valuable habitat for a large diversity of water and woodland bird species. A total of twenty seven listed species have been recorded on the floodplain, including seven species listed under international agreements such as the Latham's snipe (*Gallinago hardwickii*) and the sharp-tailed sandpiper (*Calidris acuminate*).

The Australian Wetlands database identifies the Lower Goulburn River Floodplain as an important breeding area for waterbirds, including many colonial nesting species. When inundated, the floodplain provides a productive resource for a range of waterbirds – supplying the roosting and foraging habitat needed for successful recruitment. Significant species recorded at the site include the FFG-listed Australasian bittern (*Botaurus poiciloptilus*), freckled duck (*Stictonetta naevosa*), intermediate egret (*Ardea intermedia*) and little bittern (*Ixobrychus dubius*), all of which are endangered in Victoria.

Waterbird breeding has been recorded in the lower Goulburn River and includes internationally significant species such as the eastern great egret (*Ardea modesta*) and the white-bellied sea eagle (*Haliaeetus leucogaster*). A total of 34 bird species have been recorded breeding at Gemmill Swamp Wildlife Reserve near Shepparton, including royal spoonbill (*Platalea regia*) (Figure 8) and musk duck (*Biziura lobata*) both of which are listed as vulnerable in Victoria.

Figure 8: Royal spoonbill (Photo: K. Ward)

Figure 9: Male superb parrot in shrub at Picola, Victoria (Photo: K. Ward)

The forests of the Goulburn River floodplain also provide food and habitat resources for a range of woodland bird species, including ten species listed under the *FFG Act* (1988) and the *EPBC Act* (1999). Whilst not considered water dependent, these species require a functioning forest ecosystem to supply the nesting and roosting habitat, as well as the food and water requirements needed for their survival. Important species include the nationally endangered swift parrot (*Lathamus discolor*) and the vulnerable superb parrot (*Polytelis swainsonii*) (Figure 9), both of which are classified as endangered in Victoria.

A summary of the listed bird species and their conservation significance is presented in Appendix 3.

3.4 Current condition

Changes in catchment land use since European settlement, combined with the construction and operation of Lake Eildon and other irrigation infrastructure, have impacted on the quality of the physical habitat and the ecological health of the river system. The Sustainable Rivers Audit (SRA) was conducted 2004-2007 and repeated in 2008- 2010. Both audits assessed the overall ecosystem health for the Goulburn Valley River as very poor, driven by changed hydrology and low abundances of native fish populations.

The riparian zone in the mid Goulburn varies considerably in quality and extent (width), and generally exists as a narrow strip, sometimes as little as 1-2 trees wide, with degraded understorey lacking a shrub layer and often dominated by pasture grasses. In many areas, the riparian zone is exposed to stock, as fencing is not continuous. Conversely, in the lower Goulburn, the riparian zone is generally wider and much more extensive, as well as being in better condition (floristically) and more structurally complex with shrub layers.

The relatively high incidence of non-native plant species in the Goulburn is consistent with current understanding of the effects of seasonally-modified flows (Cottingham et al., 2014b). Wetlands on the floodplain now flood much less frequently and disadvantage native plant life-cycles (Cottingham et al., 2014b). Species lists for the riparian zone record blackberry (*Rubus anglocandicans)*, an array of willows (*Salix* spp.) and exotic grass species (Australian Ecosystems 2012). Long periods without being flooded also has implications for the wetland seed bank and a return to flooded conditions is needed to ensure the native character of these system is retained.

The population structure of native fish species in the lower Goulburn system (below Goulburn Weir) is in reasonable condition, with self-sustaining populations of many species, including Murray cod and trout cod (Koster et al. 2012). In contrast, the population structure of these species between Lake Eildon and Goulburn Weir is considered to be in poor condition and are affected by cold water releases from Lake Eildon and high summer flows.

The wider Goulburn River catchment supports reduced diversity, abundance and range of many native fish species, with introduced species now dominating in many areas (Lieschke et al. 2014). A range of introduced fish species including redfin perch, carp (*Cyprinus carpio*), oriental weatherloach (*Misgurnus anguillicaudatus*) and eastern gambusia (*Gambusia holbrooki*) have abundant, self-sustaining populations in the lower Goulburn River (Koster, 2012).

Supporting golden perch populations is a key driver for environmental flow delivery in the lower Goulburn River as flow variations are required to cue spawning. However, there appears to be limited recruitment of juveniles which warrants further investigation. Murray cod and a number of other native fish species are thought to breed annually in the lower Goulburn regardless of flow levels (Koster et al, 2012).

The river banks of the Goulburn River actively erode naturally. It is unclear to what extent this is exacerbated by environmental releases. The relationship between lower bank erosion issues and environmental releases is currently being investigated as part of a five year monitoring program in the lower Goulburn.

The water quality in the Goulburn River is deemed to be generally good, with the main issue being cold water temperatures from Lake Eildon releases (Cottingham at al 2014b). Cold water pollution primarily affects the section of river below the dam during the warmer months and is not an issue for the planned timing of releases under this project.

3.5 Past management activities

Delivery of environmental water in the Goulburn River began in 1995 and has been largely focussed on delivery to the lower Goulburn. Key flow components delivered through this period include:

- provision of minimum flows of between 500 and 830 ML/day
- winter and spring freshes in the range of up to 8,500 ML/day, and
- autumn freshes of 4,500 ML/day.

As discussed above, positive ecological responses have been observed as a result of these deliveries including golden perch spawning, and recovery of instream and bank vegetation (Figure 10).

Environmental water deliveries have been complemented by a range of ongoing instream and riparian works, and the establishment of the Lower Goulburn Regional and National Parks.

Figure 10: Cable Hole photo point monitoring showing a recovery of phragmites in response to environmental flow releases between 2012 (top) and 2015 (bottom) (Photos: GBCMA)

4. Environmental benefits

4.1 Ecological objectives and targets

The long term management goal for the Goulburn River has been informed by a variety of technical studies, the Goulburn Broken Waterway Strategy, advice from scientific experts and the environmental values it supports (GBCMA, 2015a). The long term management goal is:

To protect and improve the Goulburn River's important aquatic flora and fauna, instream habitats, connected floodplains and ecological processes

The Goulburn River Environmental Water Management Plan describes the desired ecological outcomes to be achieved through flow management over the next ten years (GBCMA, 2015a). These overarching objectives encompass the more detailed ecological objectives established for the site by various flow studies and technical reports (as presented in Appendix 4), and include:

1. Increase the abundance, spatial distribution and size class diversity of key native fish species.
2. Increase the abundance and richness of aquatic and flood dependent native vegetation species.
3. Increase macroinvertebrate biomass and diversity.
4. Protect and promote natural channel form and dynamics (e.g. sediment diversity, rates of sediment transport and bank erosion rates).
5. Increase instream physical habitat diversity (e.g. shallow and deep water habitats).
6. Provide sufficient rates of in-stream primary production and respiration to support native fish and macroinvertebrate communities.

These align with the overall ecological objectives sought by section 8.04 of the Basin Plan (Table 4-1) and the anticipated ecological outcomes of the project.

Table 4-1: Links between the ecological objectives for the Goulburn River and the Basin Plan

<table>
<tr><th>Ecological Value</th><th>Overarching objective – Goulburn</th><th>Corresponding objective(s) - Basin Plan</th></tr>
<tr><td>Native Fish</td><td>1. Increase the abundance, spatial distribution and size class diversity of key native fish species.</td><td rowspan="3">▪ Protect and restore water-dependent ecosystems (e.g. rivers, wetlands and floodplains; and their plants and animals)
▪ Ensure that water-dependent ecosystems are resilient to climate change and other risks and threats</td></tr>
<tr><td>Native Vegetation</td><td>2. Increase the abundance and richness of aquatic and flood dependent native vegetation species.</td></tr>
<tr><td>Macroinvertebrates</td><td>3. Increase macroinvertebrate biomass and diversity.</td></tr>
<tr><td>Geomorphology</td><td>4. Protect and promote natural channel form and dynamics (e.g. sediment diversity, rates of sediment transport and bank erosion rates)
5. Increase instream physical habitat diversity (e.g. shallow and deep water habitats).</td><td rowspan="2">▪ Protect and restore the ecosystem functions of water-dependent ecosystems (e.g. salt export, connectivity, carbon entrainment)</td></tr>
<tr><td>Stream Metabolism</td><td>6. Provide sufficient rates of in-stream primary production and respiration to support native fish and macroinvertebrate communities.</td></tr>
</table>

Additional objectives and targets are set out in the Basin-wide Environmental Watering Strategy (MDBA, 2014). The contribution of bank-full and overbank flows to achieving these targets in presented in Table 4-2. Environmental flow recommendations have been developed to achieve these objectives, as described in section 6.3.

Although changed flow regimes have resulted in the decline of ecological values associated with the Goulburn River system, these values would recover with appropriate environmental water management. The premise of the Goulburn Constraints Measure is to find a way to increase flooding of public land (to deliver ecological benefits) while minimising impact on third parties.

To understand the project benefits, the relationship between flow rates and inundation footprint on the lower Goulburn floodplain has been examined through hydraulic modelling.

Overall, 74% (2,075 ha) of the total wetland area is inundated at the target flow rate of 25,000 ML/day. This includes 90% of the wetlands downstream of Seven Creeks, with only small incremental gains in area as flow increases.

Due to the shallow nature of many of the wetlands on the lower Goulburn floodplain, long durations are not required to fill these areas. Therefore, a peak flow of 30,000 ML/day is expected to result in approximately 84% of the total area of wetlands being filled under the preferred operating scenario.

For areas of native vegetation (across public and private land) the area inundated increases fairly steadily with flow, with over 40% (7,700 ha) of the lower Goulburn native vegetation within the flooded footprint at 25,000 ML/day.

Again, the greater proportion of inundation occurs downstream of the Seven Creeks confluence. Between Goulburn Weir and Seven Creeks the area of native vegetation within the flooded footprint is 1,396 ha at 25,000 ML/day, representing only 15% of the total native vegetation inundated in the lower Goulburn. An additional 950 ha is inundated in New South Wales (NSW) at the target flow of 25,000 ML/day however is not considered further by this project.

A summary of the expected environmental outcomes from increased bank-full and overbank flows is provided below in Table 4-2.

Table 4-2: Contribution of the Goulburn Constraints Measure to the Basin-wide Environmental Watering Strategy objectives and targets

Theme	BEWS Objective	Targets	Contribution of Goulburn Constraints Measure
River flows and connectivity	Improved connections along rivers and between rivers and their floodplains	Maintained base flows: at least 60% of their natural levels	No contribution. Base flows can be delivered without the project in place (subject to water availability).
		Improved overall flow: 30% more into the River Murray	Significantly contributes to target. The estimated increase in discharge would be determined through further modelling.
		Improved connectivity with bank-full and/or low floodplain flows: by 10-20% in remaining catchments	Target achieved in the Goulburn. The project provides the capacity to increase the occurrence of overbank flows of 1-3 years in 10.
Vegetation	Maintain the extent and improve the condition	Maintenance of the current extent of: ▪ About 360,000 ha of river red gum, 409,000 ha of black box, 310,000 ha of coolibah forest and woodlands; and existing large communities of lignum ▪ Non-woody communities near or in wetlands, streams and on low lying floodplains	Contributes to target. The project inundates over 2,000 ha of wetlands and almost 10,000 ha of floodplain vegetation, predominantly with a river red gum overstorey.
		Maintain the current condition of lowland floodplain forests and woodlands of: river red gum and black box	As above. The project allows for an improved frequency of flooding that better meets the desired water requirements of these vegetation communities.
		Improved condition of: southern river red gum	As above. An improved watering frequency is expected to result in an overall improvement in the health of river red gum trees.
Waterbirds	Maintain current species diversity, improve breeding success and numbers	Maintained current species diversity of: all current Basin waterbirds	Contributes to target. The project allows an increased frequency of suitable, diverse feeding and breeding habitat for waterbirds.
		Increased abundance: 20-25% increase in waterbirds by 2024	As above. Increased breeding opportunities can contribute to an increase in overall waterbird numbers.
		Improved breeding: ▪ Up to 50% more breeding events for colonial nesting waterbird species	Contributes to target. The project can deliver recurrent flow events needed to support colonial nesting species. The provision of bank-full flows in other years would

Theme	BEWS Objective	Targets	Contribution of Goulburn Constraints Measure
		▪ A 30-40% increase in nests and broods for other waterbirds	ensure additional breeding opportunities for other waterbirds that do not require broad-scale floodplain inundation to breed.
Fish	Maintain current species diversity, extend distributions, improve breeding success and numbers	Improved distribution: of key short and long-lived fish species across the Basin	Contributes to target. The project can provide cues for fish movement, as well as dispersing larvae into the River Murray system. The extent of benefit is influenced by flow management in the River Murray.
		Improved breeding success for: ▪ Short-lived species (every 1- 2 years) ▪ Long-lived species in at least 8/10 years at 80% of key sites	Contributes to target. The project can facilitate an increase in breeding opportunities such as cues to trigger spawning in flow dependent species, such as perch. The project can allow small-bodied native fish increased access to wetland habitat (for off-channel specialists) and the reestablishment of in-stream vegetation for shelter and spawning.
		Improved populations of: ▪ Short-lived species (numbers at pre-2007 levels) ▪ Long-lived species (with a spread of age classes represented) ▪ Murray cod and golden perch (10-15% more mature fish at key sites)	Contributes to target. As above, enhanced breeding and access to habitat can lead to improved population structure. Increased in-stream carbon would improve the productivity of the system, providing an increased food supply for fish.
		Improved movement: more native fish using fish passage	As above.

4.2 Floodplain outcomes

An improved flow regime in the lower Goulburn would make significant contributions to improving the health of a number of flood-dependent vegetation communities in the Murray Fans bioregion, including Riverine Grassy Woodland, Sedgy Riverine Forest and Floodplain Riparian Woodland, as well as protecting areas of endangered Plains Woodland and Riverine Chenopod Woodland along the River Murray.

As flood dependent vegetation communities, the overall health and species composition is reliant upon the provision of a suitable watering regime. If constraints on environmental watering in the Goulburn River are relaxed, the diversity of understorey vegetation is expected to improve over time and the extent of rare and threatened flora, such as river swamp wallaby-grass, would increase.

The project would encourage recruitment and improve tree canopy health, supported by better access to water during dry periods through an increase in soil moisture and groundwater recharge. Flow on benefits include the increased production of organic leaf material, contributing carbon to the food chain and offsetting previous impacts such as the removal of woody debris from the floodplain and river desnagging (Cottingham et al., 2014a).

A functioning forest floodplain would provide food and habitat for a range of floodplain and terrestrial fauna, such as nesting hollows for the squirrel glider and barking owl (*Ninox connivens*). The supply of food resources such as seeds and nectar would attract a diverse woodland bird community, who in turn would feed on insects within the forest reducing tree attack and improving overall health. An abundant understorey would provide foraging resources for herbivores such as kangaroos and wallabies.

The project would inundate over 2,000 ha of wetlands in the lower Goulburn system at flow rates of 25,000 ML/day, representing most of the nationally important wetlands within the reach. An improvement in plant cover, species richness and native character is expected to be observed over time. These areas would supply a diversity of food (e.g. microbes, invertebrates and small fish) and areas of deep water for diving species such as cormorants (DSE, 2011). A diverse plant structure would provide shelter for a range of species such as breeding zones for frogs and yabbies and nesting platforms for species like the endangered Australasian bittern.

The 'flashy' nature of Goulburn River flows, and shedding nature of the floodplain, means that extended flooding required for waterbird recruitment occurs primarily in wetlands within the lower Goulburn floodplain, where water is retained after flows recede (MDBA, 2012). This would be limited to deeper wetlands, such as Gemmill and Reedy swamps, where breeding of colonial nesting species has been recorded.

The project would support enhanced outcomes for waterbirds including:

- *Species diversity:* Access to a diverse range of food resources is needed to meet the requirements of different waterbird guilds, from fish eating species such as egrets to invertebrate feeders such as the grebes.
- *Species abundance:* access to an abundant food supply is needed to attract and retain large numbers of waterbirds to the site.
- *Breeding success:* Access to an abundant food supply is required to trigger most species to initiate breeding and to allow them to successfully fledge their young.

Almost 8,000 ha of foraging habitat would be provided more frequently for waterbirds. The seasonal wetting and drying regimes over a broader area would promote a more productive food web (Rogers, 2010). The project may also provide additional opportunities for colonial waterbird breeding in years where recurrent flood events occur.

4.3 Instream outcomes

It is suspected that the main channel of the Goulburn River system may be carbon poor, restricting the food availability and subsequent diversity and abundances of aquatic organisms (Cottingham et al., 2014b). Restoring flows that better connect the Goulburn River to its floodplain would deliver nutrients to the instream environment, supporting complex food webs that increase in the number and diversity of organisms (from invertebrates such as insects to the higher order animals that feed on them such as fish and platypus). Improved connectivity between the river and floodplain also allows native fish to access habitats needed to complete their life cycles.

Higher flows in the Goulburn River would aid channel forming processes by overturning substrates and maintaining riffle and pool habitat used by native fish and macroinvertebrates. The scour of fine sediment exposes bed material suitable for the growth of aquatic macrophytes, contributing to a more diverse instream environment, and provides increased habitat for macro-invertebrates via greater inundation of snags (Cottingham et al., 2014a).

The current flow regime supports beds of emergent and submerged aquatic vegetation within the main channel of the Goulburn River such as eelgrass (*Vallisneria australis*), common reed (*Phragmites australis*) and water milfoil (*Myriophyllum spp.*). The provision of higher flow components would lead to an improvement in the diversity and extent of aquatic vegetation, providing shelter for native fish and macroinvertebrates. In particular, recent surveys (Koster, 2012) have found that aquatic vegetation plays an important role in the life cycles of Murray River rainbowfish (*Melanotaenia fluviatilis*) which rely on vegetation for spawning, and possibly egg and juvenile survival.

The provision of a more variable flow regime is anticipated to result in the re-establishment of bank vegetation, leading to reduced bank erosion. Higher water levels would sustain riparian fringing vegetation, improving canopy health and providing a source of organic material and woody debris into the stream environment. Low lying wetlands would become connected to the river more often, providing a water source between large overbank flow events and ensuring the replenishment of seedbanks and increased abundances of wetland specialist fish such as Australian smelt (*Retropinna semoni*).

If undertaken, the project is expected to lead to an increase in the abundances and spatial distribution of large-bodied native fish species, such as trout cod and silver perch. The lower Goulburn River is considered an important spawning ground for golden perch, a species dependent upon flow for spawning. Although evidence suggests the species would spawn under a range of flow conditions, significantly greater responses have been observed in years associated with high river discharge and/or floodplain inundation (Koster, 2012), such as those which would be provided by the project.

4.4 Anticipated ecological benefits: mid Goulburn

In the mid Goulburn (Lake Eildon to Goulburn Weir), in the order of 800 ha of wetlands and 1,400 ha of native vegetation are expected to be inundated by the proposed flow regime.

The delivery of bank-full and overbank flows through the mid Goulburn would enhance existing ecological values, although less inundation would occur than in the lower Goulburn. Higher flows are expected to improve the health and diversity of riparian vegetation and increase the prevalence of native species in the understorey. These areas would provide a source of woody debris for the river that provides habitat for aquatic biota and increases bed diversity through the formation of scour pools (Cottingham et al., 2014b).

Reinstatement of connectivity between the river, its tributaries and the floodplain would allow native fish to access habitats needed to complete their life cycles, and move to areas of warmer water necessary to trigger spawning in some species (Koster, 2012; Cottingham et al., 2014b). These areas would provide a source of carbon to the river environment, leading to a more productive food web. This represents a diversity of invertebrate species and results in greater abundances of flow dependent and floodplain specialist fish species and supports recreational species, such as trout.

Freshwater catfish can disperse during periods of hydraulic connectivity between the river and wetland environments (e.g. Tahbilk Lagoon), providing a source population for boosting abundances across a broader scale. Improved seasonality of flows would lead to wetlands dominated by water dependent aquatic vegetation, providing a habitat mosaic across the landscape that supports frog species and provides opportunistic habitat for waterbirds.

Sediment deposited by tributary inflows would be moved through the system resulting in a more diverse instream environment, maintaining pool and riffle habitat for aquatic organisms and benches that host aquatic plant communities.

4.5 Anticipated ecological benefits: River Murray

Delivering flow peaks in the Goulburn would also provide benefits to the River Murray, both from an ecological and hydrological perspective.

As a major tributary of the Murray system (second only to the Murrumbidgee in terms of surface water availability) (MDBA, 2013) the Goulburn River plays an important role in contributing to stream flow in the mid-Murray. Increased discharge from the Goulburn River through bank-full and overbank flows could therefore contribute to flow targets set for the central Murray system and further downstream, as far as the Lower Lakes and Murray mouth. In combination with other measures proposed for the River Murray channel, the project could offset operational constraints caused by the Barmah Choke.

Higher flows carry with them organic material that contribute to the productivity of the River Murray system and facilitates the dispersal of seeds and vegetative material for the recolonisation of plants at downstream sites.

Monitoring has recorded golden perch spawning in response to freshes delivered to the Goulburn system (Koster, 2012). Additional research in the River Murray near Barmah-Millewa Forest has shown that spawning events can occur in response to quite short duration flow peaks (Raymond, 2013). The project therefore has the potential to make a significant contribution to the resilience of golden perch populations in the broader River Murray system, as well as potential source populations for the recovery of endangered fish species like trout cod and Macquarie perch.

The connectivity between populations of adult golden perch in the Goulburn River and the mid-Murray channel is considered to be important for the conservation of the species (Koster, 2012). Long term studies (Koster, 2012) indicate that golden perch can move into the River Murray to spawn when conditions are suitable, returning to the Goulburn River afterwards.

Similarly, extensive spawning has occurred in the Goulburn River following overbank flow events, such as those observed in 2010-11. Golden perch lay buoyant eggs that drift downstream in river currents and are suspected to enter the River Murray, providing another mechanism for the recovery of the species in the main channel. Monitoring of fish movement has also shown that one quarter of the fish tagged moved from the River Murray into the lower Goulburn, with seven (9% of total tagged fish) appearing to remain permanently (Koster, 2012). These results suggest that population connectivity may be important for the exchange of genetic material among populations.

The results also suggest that higher winter spring flows are important for improving the condition of fish in the pre-spawning period, leading to higher spawning responses later in the season (Koster, 2012). This theory is supported by the 2010-11 event where golden perch moved onto the floodplain accessing a ready supply of food that subsequently lead to a high magnitude spawning event (Koster, 2012). The provision of bank-full and overbank flows through this project are therefore expected to lead to greater breeding responses within golden perch and assist the recovery of the species with the mid-Murray system.

4.6 Monitoring and Evaluation Plan

A detailed scoping of the proposed Monitoring and Evaluation Plan (MEP) would be carried out if it is agreed that this project will be included in the final constraints package. The final MEP for this project would be informed by broader intergovernmental arrangements for Basin-wide monitoring and evaluation under the Basin Plan. This 'staged' approach to MEP finalisation aligns with agreed arrangements under the *Basin Plan Implementation Agreement*, where implementation tasks are to be as streamlined and cost-efficient as possible.

5. Potential adverse environmental impacts

5.1 Overview

Although environmental watering actions are designed to achieve improved ecological outcomes, they also need to take into account the potential environmental risks and how they can be managed. Potential environmental risks include things like the possibility of blackwater events, and the spread of pest plants and animals. These risks and issues are considered for all environmental watering including overbank events, as higher flows pose a different suite and level of risk.

Risk management is part of existing environmental water planning processes including the:

- *Commonwealth Environmental Water Holder's Framework for Determining Commonwealth Environmental Water Use* - that requires environmental watering actions to consider potential environmental risks, including downstream environmental risks, and measure that may be taken to minimise those risks (Commomwealth Environmental Water Office, 2013).
- *Victorian Environmental Water Holder's (VEWH) Seasonal Watering Planning process* - which has established an over-arching risk management framework that requires all parties to identify and control foreseeable adverse outcomes
- *Goulburn River Environmental Water Management Plan* (GBCMA, 2015a) – that sets out the long term strategy for the management of environmental water and guides the seasonal water planning process. Refining and adapting this plan is a key mechanism for mitigating potential adverse environmental outcomes.

A high level assessment of the potential adverse environmental outcomes was completed in line with the requirements of AS/NZS ISO 31000:2009 and the GBCMA Risk Assessment Framework (Tranter, 2015). The assessment considered the potential environmental risks in the Goulburn River below Lake Eildon, as well as the receiving River Murray (Tranter, 2015).

5.2 Summary of significant environmental risks identified

Information on the full suite of risks considered by the assessment process are documented in the *Goulburn Constraints Management Project: Risk Management Strategy* (Tranter, 2015). The scope of the assessment is limited to those risks associated with the project. The cumulative risks associated with the implmentation of other constraints or SDL measures was not considered as part of the assessment.

Risks rated significant or higher prior to the management controls are summarised in Appendix 6.

Generally, the risks seem well within the scope of risks that can be managed by normal or current controls, as discussed below.

Residual risks

Following the implementation of management controls, the only remaining significant residual risk is increased populations of exotic fish species, such as carp, as there are currently no effective control actions for managing this issue. This is an issue common to all flood events (natural or managed) with overbank flows and research into control methods is ongoing.

Although the risk has potential within reach and downstream impacts, the residual risk is deemed to be acceptable given the scale of the potential ecological benefits to be generated by the project and the already ubiquitous presence of these pest fish in the region. Changes in carp populations can be detected though fish sampling programs however effective management responses are limited.

Salinity risks

The Shepparton Irrigation Region has a long history of land and water management, therefore much is known about salinity and groundwater issues within the region. The risk assessment panel included members with specific regional expertise and considered potential salinity groundwater issues for the river, its floodplain (private and public) as well as possible downstream impacts.

Salinity risks associated with the project were determined to be low (Jacobs, 2015). The main reasons for this are:

- the lower Goulburn floodplain contains relatively fresh groundwater
- groundwater levels are relatively deep, generally below the threshold for significant evaporation
- there is only moderate potential for vertical infiltration as a result of a short duration flood event
- the potential for lateral movement of groundwater after a watering event is low to moderate.

The implications in the context of Victoria's obligations are that the salinity effect at Morgan is likely to be negligible and therefore is not reportable under Schedule B to the MDB Agreement and the Basin Plan (Jacobs, 2015).

Additional work recommended to monitor and confirm salinity risks includes:

- an upgrade of the water table monitoring network to detect any potential changes in groundwater levels or salinity risks
- a preliminary salinity impact assessment against the benchmark model run (subject to a decision to proceed with the project)
- time series sampling of the salinity of return flows to the River at the end of the environmental watering event.

The nature of any downstream salinity and/or water quality impacts, and any potential cumulative impacts with other measures under consideration through the sustainable diversion limit adjustment mechanism process cannot be formally ascertained at this time. This is because such impacts would be influenced by other measures that may be operating upstream of this site, and the associated total volume of water that is recovered for the environment.

It is expected that likely or potential downstream/cumulative impacts would become better understood as the full package of adjustment and constraints measures is modelled by the MDBA, and a final package is agreed to by Basin governments.

5.3 Further work

The outcomes of the risk assessment provides a preliminary basis for prioritising mitigation strategies and measures based on currently available information. A more detailed risk assessment would be carried out should the Basin Ministers decide to proceed further with the project.

6. Hydrology of the system and environmental water requirements

6.1 Current hydrology

As one of the largest Victorian tributaries of the River Murray, the Goulburn River plays an important role in meeting the water need of communities in a large section of northern Victoria.

Development in the Goulburn River catchment has changed the patterns of flow within the river and its movement across the landscape. Before development, floods tended to be peaky, of short duration, and generally several events occurred per year. These floods would drain rapidly off the floodplain, except where water ponds in depressions (wetlands). These depressions would then be topped up by recurring flood events (DSE, 2011) providing a persistent water source for native flora and fauna.

Flow along the Goulburn River has been highly modified by two major features: Lake Eildon and Goulburn Weir (Figure 11). Current regulated operation of the river system is largely based on irrigation requirements and minimum flow provisions (section 6.2). Irrigation requirements generally follow crop demand patterns and do not vary significantly during the summer irrigation season. Generally, regulated flows do not exceed irrigation demands, although limited provision for additional releases exist in the Goulburn Bulk Entitlements (which may be granted to a water corporation, VEWH and other specified bodies). Outside of flood operating conditions, GMW would not release water from Lake Eildon or Goulburn Weir to supply orders if there is a risk of flooding.

A comparison of the natural and current flow regime from Murchison to Shepparton is shown in Table 6-1. Floods in the range targeted by the Goulburn Constraints Measure now occur significantly less often, with significantly greater periods between events.

Table 6-1: Summary of natural and current flow regime from Murchison to Shepparton

Flow (ML/d)	Flood frequency (number per 10 years)		Mean duration in spring (days)		Maximum period between events (years)	
	Natural	Current	Natural	Currant	Natural	Current
25,000	25.0	7.5	9	6	2.8	7.0
40,000	14.6	3.2	5	3	2.9	9.9

Flood frequency: average number of flood events per ten years
Duration: mean duration of high spells during September to November
Maximum period between events: based on modelled daily flow at Shepparton from July 1896 – June 2006
Source: DSE, 2011

DSE (2011) found that under current conditions, flow events from Murchison to Shepparton of between 25,000 and 55,000 ML/d:

- occur 20% to 30% less often compared to unregulated conditions
- are 50% to 70% shorter compared to their unregulated duration
- have a maximum period between events that is 2.5 to 3.5 times longer than in the unregulated condition.

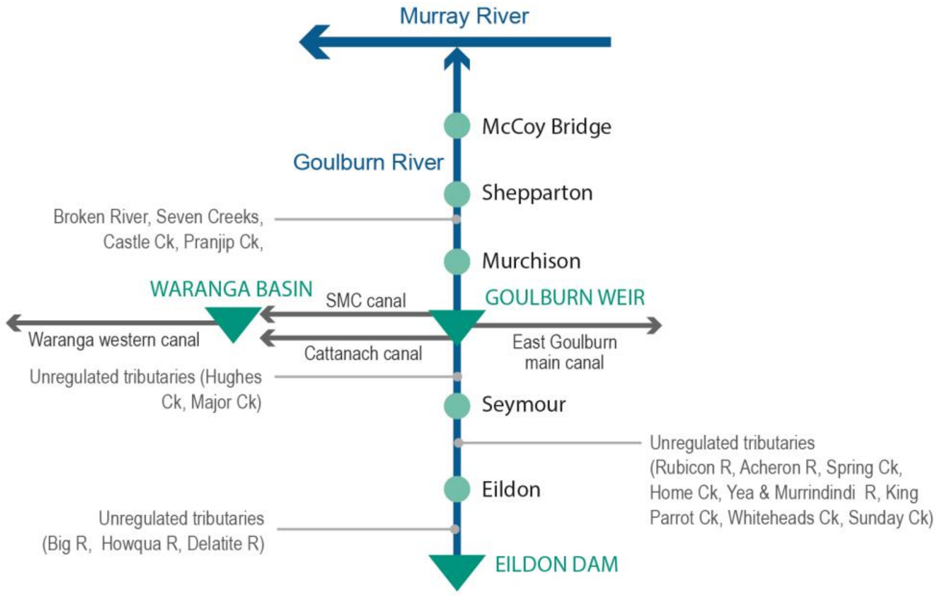

Figure 11: Schematic of the Goulburn River water supply system

Lake Eildon is located in the river's upper catchment and has a capacity of 3,334 GL, which is approximately twice the average annual inflow in the Goulburn River (GBCMA, 2015a). Water released from Lake Eildon is diverted for irrigation, urban and environmental use, supplying about 60% of water used in the Goulburn Murray Irrigation District (GMW website). With such a large storage capacity, operation of the lake fully regulates downstream flows in all but wet years (GBCMA, 2015a).

Goulburn Weir is approximately 235 km downstream of Lake Eildon (Figure 11). It holds 25 GL and is held close to full capacity to facilitate water diversion into irrigation channels. Water is also diverted to the Waranga Basin, which has a storage capacity of 432 GL (GBCMA, 2015a), and is used to capture winter and spring flows from tributaries downstream of Lake Eildon. Goulburn Weir and its operation (along with Lake Eildon) have reduced the average annual downstream flow to 1,340 GL, less than half the estimated pre-regulated flow (GBCMA 2015).

The harvesting to storages has resulted in a significant reduction of flow within the Goulburn River (CSIRO, 2008), as shown in Figure 12. In the 2013-14 winter/spring, water harvesting reduced the natural river flow from a peak flow of about 40,000 ML/day to a peak flow of less than 10,000 ML/day; i.e. from significant floodplain watering to only half filling the river channel.

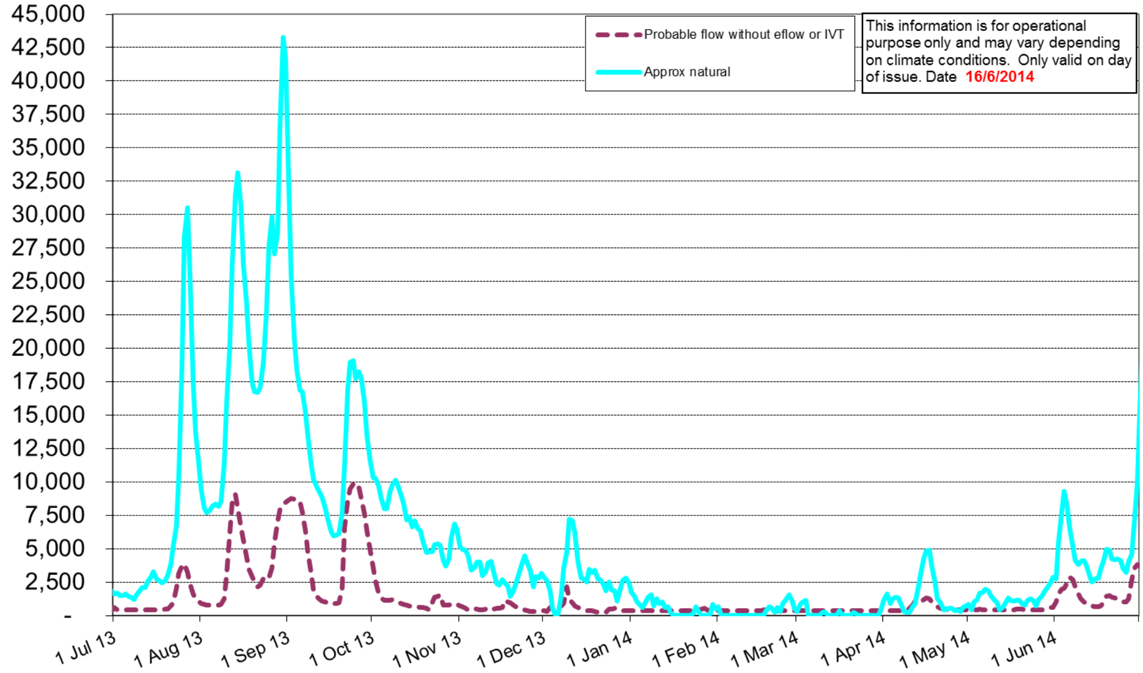

Figure 12: Probable versus approximate natural flows in the Goulburn River at McCoys Bridge during 2013-14

The Goulburn River is actively managed by GMW who manages the storage and regulated release of water for downstream use in northern Victorian catchments (GBCMA, 2015a). GMW has a wide range of customers that require different amounts of water at different times, which has resulted in a changed seasonality of flow within the river.

Lake Eildon and its operation have altered the river flow regime immediately downstream of the storage such that low flows now occur in winter and spring due to water storage, and higher flows now occur in summer and autumn due to releases to meet irrigation and other consumptive demands. However, Goulburn River flows below Lake Eildon progressively increase downstream due to tributary inflows (Figure 11), particularly in winter and spring (GBCMA, 2015a).

Downstream of Goulburn Weir the river retains some natural seasonal flow pattern due to the influence of tributaries such as the Broken River and Seven Creeks, and the diversion of irrigation water at the Goulburn Weir during summer and autumn. Significant flows may be released in summer and early autumn from Goulburn Weir to the River Murray as Inter-Valley Transfers (IVT) to supply water entitlements traded from the Goulburn River to the River Murray system (GBCMA, 2015a).

Water starts inundating the Goulburn River floodplain at different flows along the river. As an indication, Bureau of Meteorology (BoM) minor flood levels (indicating low-lying areas next to water courses are inundated) along the Goulburn River are as follows:

- 3 metres (14,500 ML/d) at Eildon
- 4 metres (21,700 ML/d) at Trawool
- 4 metres (24,800 ML/d) at Seymour
- 9 metres (33,100 ML/d) at Murchison
- 9.5 metres (26,100 ML/d) at Shepparton
- 9 metres (28,300 ML/d) at McCoys Bridge.

However, flows commence going out of the river at lower flows than these as distributary channels start to become engaged. River channel capacity immediately downstream of Lake Eildon is between 9,000 and 10,000 ML/day, and at Shepparton bank-full flow is estimated to be approximately 18,000 ML/day.

On the floodplain downstream of Shepparton, artificial levees and other structures obstruct flood flows (Cottingham et al 2003) and have significantly changed where water spreads across the landscape. The Loch Garry regulator prevents the flow of water to the north of the Goulburn River main channel during unregulated flow events of about 40,000 ML/day at Shepparton.

6.2 Current infrastructure operations

Development of water management infrastructure to harness the waters of the Goulburn system commenced shortly after European settlement of the area, in order to meet the water needs of the settlers looking to establish farms and towns in the region.

Key milestones in the development of water related infrastructure in the Goulburn system are:

- 1891 – Completion of Goulburn Weir, which was the first major diversion weir for irrigation in Australia.
- 1908 – Waranga Basin (first stage) completed, creating an off-stream storage.
- 1921 – Waranga basin embankment raising was completed to enlarge the storage to its current capacity
- 1929 – Sugarloaf Reservoir (377 GL) was completed, just upstream of the location of the current Lake Eildon embankment.
- 1955 – Construction of Lake Eildon was completed and filling of the storage commenced.

The current operating arrangements for the Goulburn River system have evolved over the period since the construction of these assets. These operating arrangements were developed and documented incrementally, with the arrangements distributed across various procedures, guidelines and manuals for the operation of assets and the water harvesting practices.

In 1992, the Victorian government commenced the development of the first Bulk Entitlement Order in Victoria, to codify the rights to water in the Goulburn River system. This culminated in the issuing of the Bulk Entitlement (Eildon – Goulburn Weir) Conversion Order in 1995.

This bulk entitlement order established:

- the entitlements to water from the Goulburn system
- the cap on the volumes of water that could be extracted from the system to supply these entitlements
- the capacity of the harvesting assets that could be used to harvest, store and divert water from the system
- key operating practices and constraints (e.g. flood mitigation pre-releases, minimum passing flows etc.). The computer modelling that supported the Bulk Entitlement Order also documented the water allocation and management rules and practices that applied.

The key phases of current system operations are the harvesting phase and the water delivery phase. The sections below describe the operations during these phases for Lake Eildon and Waranga Basin (i.e. Goulburn Weir).

Harvesting phase

Water harvesting occurs during the winter/spring period, when inflows to the river system are at their highest levels. Inflows above Lake Eildon (which average approximately 1500 GL per annum) are harvested and stored in Lake Eildon. During the winter/spring period, if there is no irrigation demand, releases from Lake Eildon would only be the minimum passing flows, which range between 120 ML/d and 250 ML/d depending on seasonal conditions.

Lake Eildon is filled in a controlled manner over the water harvesting period (i.e. from May onwards), so that there is a 95% probability that the storage will be full by 1 October under average conditions. Under wet conditions, the target filling date is delayed until 1 November. The storage operator, GMW, is authorised to make managed releases if the storage level rises above the filling targets established to meet these objectives. The overall purpose of these additional releases is to retain some air-space in the reservoir during the winter/spring to provide a measure of flood mitigation benefit to downstream communities, whilst not creating significant risks to overall water availability for entitlement holders.

Downstream of Lake Eildon, water harvesting activities focus on diverting a portion of inflows to the system below Lake Eildon out of the river at Goulburn Weir and storing them in Waranga Basin for use during the irrigation demand period. The mid Goulburn catchment between Lake Eildon and Goulburn Weir is highly productive, with average annual inflows only slightly lower than those received above Lake Eildon.

The ability to divert water to Waranga Basin in the harvesting period is constrained by the maximum capacity of the Stuart Murray and Cattanach Canals (Figure 11) which connect Goulburn Weir to Waranga Basin. The maximum combined capacity of these canals is approximately 7,200 ML/d. Any inflows to Goulburn Weir above this level will spill through the weir and continue down the Lower Goulburn. The filling of Waranga Basin is also managed in a controlled fashion with the aim of just filling the storage as irrigation demand develops (usually in late spring). This ensures that the storage is not held at full supply for extended periods, which can lead to wave damage on the embankment in high winds.

During the irrigation demand period, the level in Waranga is progressively drawn down, with the aim of having the storage at its minimum operating level at the end of the irrigation season. The objective of this activity is to retain water in the uppermost storage (Lake Eildon) and maximise the potential for harvesting flows into Waranga Basin during the water harvesting phase.

Minimum passing flows at Goulburn Weir range between 250 ML/d and 400 ML/d, depending on the time of year.

Water delivery phase

Historically, the water delivery phase has been driven by meeting the needs of consumptive water users, which has been dominated by irrigated agriculture. Major irrigation sectors supplied from the Goulburn system include dairying, horticulture and mixed cropping and grazing enterprises. As rainfall reduces in the late spring/summer, irrigation demand increases to meet the water needs of these crops. The irrigation supply season within the irrigation areas nominally runs from mid-August to mid-May, however the major demand period generally occurs from November to April, depending on seasonal conditions.

In order to meet irrigation requirements, the storage operator estimates the likely demands based on an assessment of a range of data including water orders, historical demand patterns, weather forecasts and water availability. Demands at Goulburn Weir are met by using a combination of releases from Lake Eildon and harvesting inflows from unregulated tributaries from the mid Goulburn reach. During the water delivery operations, releases from Lake Eildon are managed to avoid overbank flows and no private land is subject to inundation.

Water is diverted at Goulburn Weir to meet irrigation demands within the Goulburn component of the Goulburn Murray Irrigation District. Maximum diversion rates can reach approximately 9,900

ML/day. Water stored in Waranga Basin is also drawn on to meet peak demands which can exceed the capacity of direct diversions from Goulburn Weir.

Demands downstream of Goulburn Weir are met by unregulated inflows to the lower Goulburn reach, together with supplementary releases over Goulburn Weir. These demands include diversions from the lower Goulburn and transfers from the Goulburn to the Murray system (e.g. the Murray system operator can call for water from the Goulburn Inter-Valley Transfer account to cover volumes of water traded from the Goulburn system to the Murray system).

6.3 Reference to desired flows in environmental watering requirements

A range of studies have been undertaken to determine the environmental flow requirements of the Goulburn River and its floodplain (Cottingham P S. M., 2003; Cottingham et al, 2007; Cottingham et al, 2011; Cottingham et al, 2014a; DSE, 2011). Collectively the assessments identified flow recommendations that achieve flow objectives for all environmental assets and aim to promote longitudinal and lateral connectivity.

The environmental flow recommendations are expressed as flow components which can be largely characterised as follows:

- **Base flows** (or low, in-channel flows) that maintain aquatic habitat for fish, plants and invertebrates. Base flows comprise long-term seasonal flows and are usually delivered throughout the year as low volume (<1,000 ML/day at Shepparton) surface flows.
- **In-channel fresh events** are small-to-medium flow events (up to 8,500 ML/day at Shepparton) which inundate benches within the river channel, replenish soil water for riparian vegetation, provide cues for fish spawning and access to a diversity of habitat for aquatic biota. They are relatively short in duration (up to 14 days) and occur in most years, or possibly multiple times within a year.
- **Bank-full flows** are the larger flow events (up to 14,000 ML/day at Goulburn Weir) that fill the river channel and may inundate flood-runners in low lying areas of the floodplain. These flows are important for maintaining bed diversity, native fish recruitment and colonisation, regeneration of native riparian species and to retain natural seasonality for macroinvertebrate life stages.
- **Overbank flows** are the larger flow events that fill the river channel and low parts of the floodplain. They are important for a range of floodplain processes to occur e.g. healthy wetland systems that support fish and waterbird breeding, as well as the transfer of food and organic material that support productive instream foodwebs (MDBA, 2014; GBCMA, 2015).

While the Goulburn Constraints Measure aims to deliver small overbank flows, a range of other environmental water entitlements will be used to meet the other flow requirements of the river system. Large overbank flood events would not be delivered by the project and will only occur as a result of natural flooding.

An additional benefit of the project is the ability to deliver bank-full flows, which have previously been constrained by agency concerns over potential liability associated with the risk of flooding private land.

An overview of the contribution of the different flow components in meeting the riverine and floodplain objectives are summarised in Appendix 4.

Further detail on the full suite of environmental flow recommendations for the Goulburn River is presented in Appendix 5.

6.4 Proposed changes to flow regime

The Goulburn Constraints Measure aims to restore the frequency of minor flow peaks in the lower Goulburn River by delivering an additional one to three small overbank flows (25,000 ML/day) per decade (on average) for short durations (less than a week). Event duration may be shorter if the total duration is provided over the winter/spring period.

These events would occur in winter and spring (July to October) and match the time of year when rain and unregulated tributary flows typically occur in the Goulburn River. Importantly, the project may provide a greater capacity to deliver flows during drier years when floodplain plants and animals need the water most (Jacobs, 2015a).

The proposed flow regime considers both the third party impacts and previous overbank flow recommendations. These recommendations (DSE, 2011) consider how often floods should occur in the lower Goulburn in terms of both 'event years'**,** the number of years in ten when overbank flows occurred (Table 6-2), and the number of events **within** an 'event year' (Table 6-3).

The flow recommendations are described as target flows for the Shepparton flow gauge, which is known to achieve the desired rates of inundation downstream. As discussed in section 7, these target flows could be achieved by augmenting flow peaks in the Goulburn generated from the unregulated streams downstream of Lake Eildon (Jacobs, 2015a).

Table 6-2: Recommended operating regime adapted from DSE (2011)

Target flow at Shepparton	Season	Duration	Current Event years/ 10 yrs	Recommended Events years/ 10 yrs	Maximum time between events[1]
25,000 ML/d	June to November	~5 days	<6	Lower – 7 **Optimal – 8** Upper – 10	3 years

[1] recommendation based largely on the maximum tolerable interval between flooding for the floodplain EVCs

Table 6-2 shows an additional one to three small overbank event years is needed on average per decade to reduce the maximum time between events and meet the desired frequency of overbank flows flow the lower Goulburn River.

As discussed in section 2.1, the shedding nature of the floodplain means that a higher (peak) flow would need to be targeted to enable this duration to be met. Therefore, the peak flow of 30,000 ML/day at Shepparton is proposed.

6.5 Frequency within event years

Recurrent flood peaks within an event year are recommended to meet the duration requirements of floodplain fauna, particularly native fish and waterbird breeding (DSE, 2011). The recommended number of events in an event year for the Goulburn River at Shepparton is shown in Table 6-3.

Table 6-3: Frequency of events within an event year

Flow at Shepparton	Mean number of events within an event year		Mean number of events per 10 years	
	Lower	Upper	Optimal	Natural
25,000 ML/d	2	3	16 - 24	24

Recurrent flooding is an important aspect of the natural hydrology of the Goulburn River and critical to maintain its wetland ecosystems. The lower Goulburn River floodplain is generally a ‘shedding’ floodplain with scattered ‘ponding’ wetlands (e.g. Gemmill Swamp and Reedy Swamp) located throughout the floodplain.

Ponding duration is driven by flow frequency during the year. Recurrent floods top up the wetlands extending the period of wetted habitat. The required ponding duration identified in the overbank flow recommendations (DSE, 2011) is based on the needs of fauna, particularly waterbird breeding. In ponding wetlands, the flow frequency (rather than duration of high river flows) is considered to be the main determinant in achieving required ponding durations.

The importance of recurrent flood events (within a year) for key biota is described below:

- **Fish:** Follow up events (2 to 3 in a year) provide opportunities for fish (that moved onto the floodplain during the initial flood event) to move between wetlands and the main channel in successive events as they mature.
- **Waterbirds:** Recurrent flows are important for providing the appropriate conditions for the recruitment of waterbirds, topping up wetlands and maintaining the requirements for water under or near nest sites and deep water for feeding by diving ducks.
- **Woodland birds:** Follow up floods are suspected of playing an important role in protecting the condition and productivity of the vegetation, supporting woodland bird recruitment by promoting the flowering required by fruit or nectar eating species.
- **Frogs:** Successive flood peaks **c**ontribute to the diversity and extent of frogs by extending the duration of natural ponding and providing the wetland habitat needed to meet breeding requirements.

The changes proposed by the project may include watering activities that provide recurrent flooding, by either delivering an additional event after a natural one or by delivering more than one peak within a given season.

7. Proposed operating arrangements

7.1 Overview

The proposed operating regime has been designed to generate additional small overbank flow events in the lower Goulburn reach during the spring, to increase both the number of years with events and the number of events within a year. The targeted range for these events is 25,000 – 30,000 ML/d at Shepparton (refer to sections 6.3 and 6.5 for further details on the targeted frequency, magnitude and duration of events).

The additional overbank events would be generated by supplementing unregulated inflows from tributaries from two major sources:

- Additional releases from Lake Eildon. The rate of additional release would be managed so that the maximum flow immediately downstream of Lake Eildon (at Alexandra/Molesworth) doesn't exceed 10,000 ML/d. This helps ensure unacceptable impacts in the mid Goulburn reach are relatively limited and can be addressed through implementation of a package of feasible measures.
- Additional releases to the lower Goulburn reach by ceasing diversions to Waranga Basin and passing these flows downstream over Goulburn Weir, together with any other mid Goulburn inflows and Lake Eildon releases.

7.2 Key features of the proposed operations

The key features of the proposed operational arrangements are summarised below:

a. At the beginning of each water year, the environmental water manager would nominate the preferred requirements for overbank flows in the lower Goulburn in accordance with the adopted environmental watering regime.
b. Watering proposals are prepared by the environmental water manager and submitted to the Victorian Environmental Water Holder (VEWH) for consideration. If deemed a priority for that season, VEWH would allocate water from the environmental water account.
c. In years when watering is desirable, the system operator, in consultation with the environmental water manager, would monitor the BoM's seven and 30 day rainfall and streamflow forecasts to identify events that are likely to produce tributary inflows that are suitable for supplementation.
d. An assessment would be made of the capacity to supplement expected streamflows to determine if an event can proceed. The key considerations would include the current level of release from Lake Eildon and diversions to Waranga Basin. For example, if significant releases are already being made from Lake Eildon and no water is being diverted at Goulburn Weir for harvesting into Waranga Basin there is minimal capacity to supplement any additional inflows, so a managed release event would not proceed.
e. When suitable tributary flow conditions are forecast to occur, diversions to Waranga Basin would be ceased and additional flows directed downstream over Goulburn Weir. Event planning would determine the appropriate timing to coincide with the tributary flows. Given that Goulburn Weir is only two days river travel time from Shepparton, sufficient lead time is available for decisions on ceasing diversion to Waranga Basin to be based on actual streamflows observed in the mid Goulburn River and on tributary streams.

f. For events where a larger flow supplement is required to meet the environmental flow requirements, additional releases would be initiated from Lake Eildon, up to a maximum total flow of 10,000 ML/d downstream of the storage at Alexandra/Molesworth, taking into account flows from unregulated tributaries such as the Acheron and Rubicon Rivers. Due to the significant travel times from Lake Eildon to the lower Goulburn, many of these Lake Eildon release decisions would be based on streamflow and rainfall forecasts.
g. During each environmental release, the system operator would closely monitor rainfall forecasts and data on rainfall and streamflow from catchment monitoring stations. This data would be used to run rainfall-runoff modelling tools to estimate streamflows that would be experienced during the event. Supplementary environmental releases would be adjusted as necessary, within the constraints established for environmental watering actions, to maximise the effectiveness of the event. Importantly, where forecast rainfall is expected to generate streamflows above the maximum targeted levels for supplemented flows, releases from Lake Eildon would be reduced or ceased and diversions to Waranga Basin would recommence to avoid any impacts due to supplemented flows exceeding the capacity of the mitigation measures put in place as part of the project.
h. Regulating gates on upgraded outlet structures through the lower Goulburn levees would be closed during events to contain flows within the levees to maximise wetland and floodplain vegetation watering. These outlet structures are located at Hancock's Creek, Hagen's Lane, Wakiti Creek and Deep Creek. After the event passes, the gates on these regulators would be opened to the default positon to pass natural flood events. These regulating structures would also form part of the risk mitigation actions if tributary inflows are higher than planned. In such an event, the actions noted in the point above would be implemented (i.e. reduced Lake Eildon releases and recommencement of diversions to Waranga Basin). As the event reverts to natural flows, Hancock's Creek, Hagen's Lane, Wakiti Creek and Deep Creek regulators would be re-opened to allow floodwater to pass through the levees as it does under current conditions.
i. Analysis of historic flow records over the last 55 years indicates that there are suitable events that could be supplemented in May and June. However, in all of these years there are subsequent events that are equivalent in size or larger, and can therefore be supplemented with lower environmental water inputs. Accordingly, it is proposed that tributary inflow events would only be supplemented during the July to October period.

GMW is generally supportive of the proposed changes at a conceptual level and would work closely with the proponent to refine the operational arrangements, should the project proceed.

7.3 Supporting investigations

Modelling has been undertaken to identify and test a range of operational approaches (Jacobs, 2015a). There are a number of challenges in supplementing tributary inflows that were considered in developing the proposed approach, including the physical travel time for the additional releases to reach the lower Goulburn, and development of processes to ensure that monitoring and forecasting lead times for tributary inflows can be aligned with the travel times for delivery of supplementary flows.

As shown in Figure 13, releases from Lake Eildon take approximately 2.4 days to reach Goulburn Weir, and a further two days (approximately) for releases over Goulburn Weir to reach Shepparton, where they can supplement flows from the Broken River, which is one of the major lower Goulburn tributaries. In order to provide sufficient lead time to enable effective supplementation of natural flow events, approximately six days lead time is required to initiate Lake Eildon releases, increase them in a controlled manner to the desired peak rates, and for flows to travel down the Goulburn River to the lower Goulburn.

Jacobs (2015a) found that the flow travel time from Lake Eildon to Shepparton is longer than any other flow travel time in the Goulburn (excluding upstream of Eildon) and Broken valleys. Of particular note is that the flow characterisation review identified that of the flood events, a large proportion of the flow was contributed by the ungauged catchment area upstream of Trawool. This area is between zero and 1.5 days downstream of Lake Eildon.

The Broken River at Orrvale was also identified as an important contributor to a significant number of events. This is over three days travel time downstream of Eildon. Therefore, if a release was initiated from Eildon on the basis of waiting for a peak flow at Orrvale to occur, the increase in flow rate due to the release from Lake Eildon would not arrive at Shepparton until three days later.

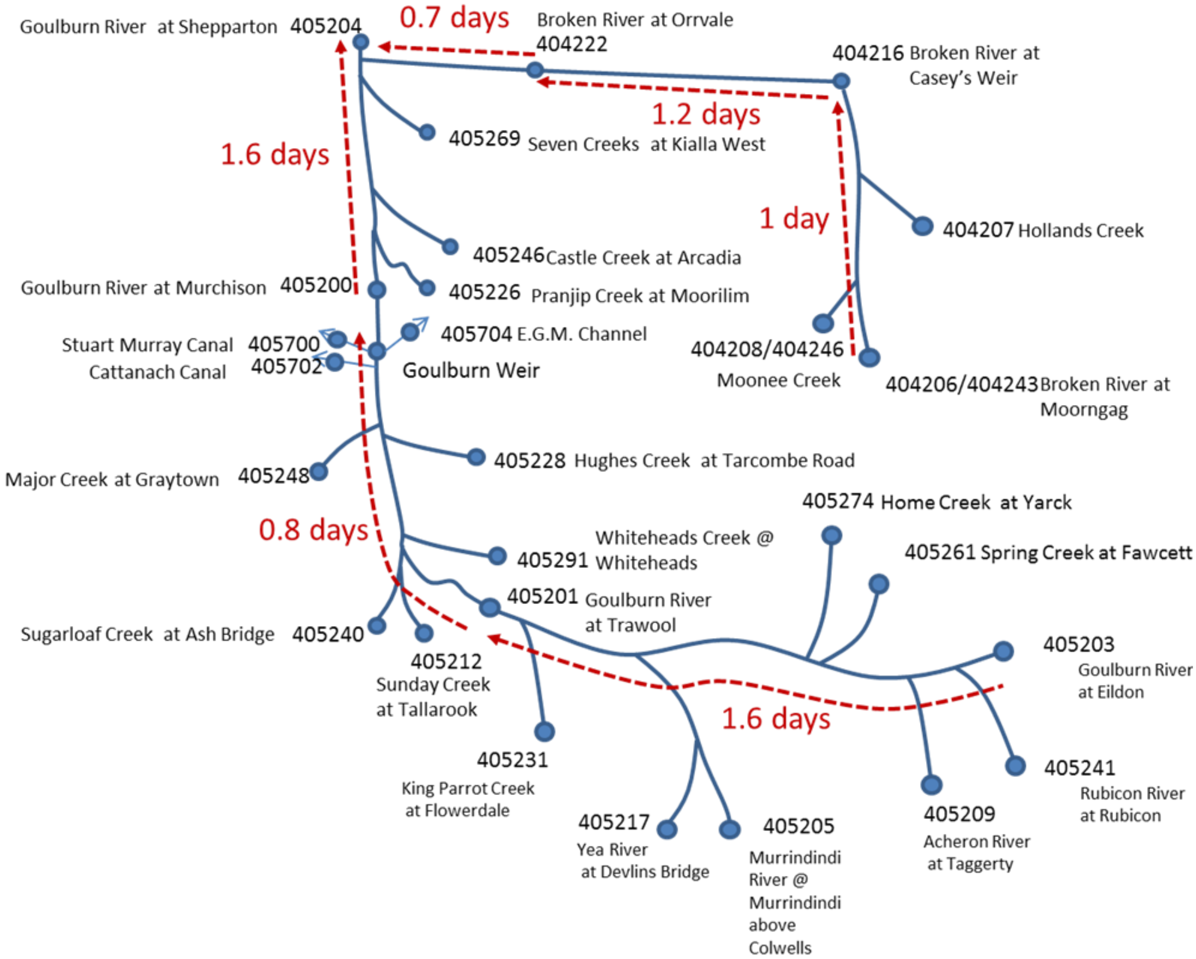

Figure 13: Transit times between Lake Eildon and Shepparton (Jacobs, 2015a)[4]

[4] This schematic shows travel times based on calibrated values using daily timestep data. Events vary in travel time to some degree. Further work could be undertaken using data at a timestep less than a day such as hourly data to investigate variations in travel time.

Hypothetical operations were modelled using these proposed arrangements for the 55 years from 1960 to 2014. The outputs show a significant increase in the number of overbank flow events in the lower Goulburn reach compared to current operating conditions. Table 7-1 provides the results of this modelling.

Table 7-1: Estimated changes in the number and frequency of flows at Shepparton with proposed flow supplements

Peak Flow Threshold at Shepparton (ML/d)	Number of events over 55 years between 1960 and 2014		
	Current conditions	With ceasing Waranga Basin diversions	With ceasing Waranga diversions plus Lake Eildon releases up to 10,000 ML/d)
15,000 - 25,000	85	73	39
>25,000	45	59	93
Total	**130**	**132**	**132**

Table 7-1 shows that the proposed operating strategy is feasible. There are currently 45 events greater than the target flow of 25,000 ML/day (35% of total). This can be increased to 59 events (45% of total) by ceasing diversions to Waranga Basin, and to 93 events (70% of total) by also releasing from Lake Eildon.

7.4 Proposed operating tools

A range of new operating tools and procedures are needed to provide the capabilities necessary to effectively manage environmental flow releases to supplement tributary inflows. These are described below and include:

- improved rainfall and streamflow monitoring
- e-Water Source modelling tools
- data interfaces between BoM and GMW systems
- further development of BoM streamflow forecasts, and
- enhanced notification services.

Improved rainfall and streamflow monitoring

Enhancements to the existing rainfall and streamflow monitoring network in the Goulburn catchment include:

a. Additional streamflow and rainfall monitoring stations would be installed to monitor significant tributaries of the Goulburn River upstream of Trawool.
b. This would also include installation of an additional streamflow gauging station on the Goulburn River between Eildon and Trawool.

e-Water Source modelling tools

DELWP is currently working on the implementation of the e-Water Source modelling platform as the new tool to replace REALM as the primary hydrologic modelling tool for northern Victorian water systems.

Unlike REALM, which functions solely as a long-term scenario modelling tool, Source includes rainfall-runoff routing routines and has the capability to be run in “operational” mode to support real time decision making on water systems management. As part of this project, it is proposed that these real time operational capabilities would be calibrated and implemented to support the management of environmental flow activities in the Goulburn system.

This is an important action, as it would provide the capability to estimate tributary inflows during events and reduce supplementary environmental releases in order to avoid unacceptable impacts from higher than planned flow rates. This flow forecasting and management capability, in conjunction with the “ buffer” allowance on infrastructure to provide additional freeboard above the targeted maximum environmental flows, provides a critical risk mitigation action (refer section 8 for further details on risks).

Data interfaces between BoM and GMW systems

Development of data interfaces between BoM and GMW systems would allow timely access to high quality data is an essential input to the water management decision making and system modelling activities that would underpin supplementary environmental water release activities.

GMW already has extensive access to rainfall and river height data in the Goulburn River system. Additional automated interfaces would be developed to transfer BoM forecast data to GMW water management systems. As well as supporting water management activities in the lead up to and during events, this data would also be used as part of a structured adaptive management process to better understand river flow behaviour under a range of different conditions and to improve the predictive capabilities of the models.

Further development of BoM streamflow forecasts

The BoM provides a 7-day forecasting service for streamflow in key river catchments across Australia. Forecasts are currently provided for two sites in the Goulburn catchment; however, the BoM intends to extend this service. Subject to funding, the BoM intends to develop rainfall and streamflow forecasting for all gauging sites in the Goulburn (and Murray-Darling Basin). This would include forecasts up to 30 days (sub daily up to a week, and aggregated days to 30 days).

It is proposed that the enhanced forecasting services would be developed in years 1 to 3 of the project, and then interfaced to GMW’s systems in years 4 and 5.

Enhanced notification services

As overbank environmental releases would not be covered by traditional flood warning services, it is proposed that notification services would be developed to provide timely warnings to communities adjacent to the sections of the Goulburn River that may be affected by environmental releases. Effective notifications would allow landholders to move stock and assets (e.g. vehicles, temporary pumping equipment) out of the area to be inundated during an event.

The proposed notification services would leverage off the work and learnings developed for delivering bushfire alerts. Enhanced notification services are also consistent with the policy direction proposed in Revised Draft Victorian Floodplain Management Strategy, and would also have the potential to provide valuable warning benefits to these communities during natural flooding events.

7.5 Required changes to current operations

Changes to current operating procedures and accounting arrangements will also be needed if the project proceeds, as described below.

Water accounting

Development of appropriate water accounting protocols for the proposed operating arrangements is needed. Releases from Lake Eildon can be accounted for at the point of release, however new accounting protocols are required to ensure that the water used to supplement tributary flow events is properly accounted for and that the reliability of water access entitlements is protected.

New protocols would also be needed to account for the additional releases over Goulburn Weir by ceasing diversions to Waranga Basin. Releases over Goulburn Weir can be measured, however releases would only affect entitlement holders if Waranga Basin fails to subsequently reach the same level that it would have if diversions had not ceased during an environmental watering event. Any shortfall in harvesting to Waranga that ultimately arises during the water year would need to be debited from environmental water accounts to ensure no loss of resource to entitlement holders.

Similarly, one of the proposed risk management strategies to manage third party impacts is to recommence harvesting into Waranga Basin if rainfall increases tributary flows above target levels. To the extent that this process results in the harvesting of environmental releases from Lake Eildon into Waranga Basin over and above that which would have been possible without a watering event, accounting processes would need be developed to ensure an appropriate credit is provided to environmental water accounts. This is most likely to occur in circumstances where increased tributary flows downstream of Goulburn Weir (which could not have been harvested) require the diversion of Lake Eildon releases into Waranga Basin.

Development of revised operating procedures

Current river operating procedures for the Goulburn system would need to be revised and updated to support supplementary releases for overbank environmental releases. This review would need to incorporate the risk management actions that have been identified to manage flows within the adopted target limits during supplemented flow events.

This may include adjusting the timing of filling targets for Waranga Basin, to ensure that there is a small amount of airspace reserved during periods when release events are expected to occur. This would ensure that water released from Lake Eildon can be diverted to Waranga Basin if downstream tributary inflows increase unexpectedly during an event. If the reservation of airspace for this purpose ultimately results in a reduction in the resource harvested into Waranga Basin in the water year, the shortfall would need to be debited against environmental water accounts.

The new system management procedures would also document the notification, water ordering and consultation processes between the environmental water manager and the system operator that are required before, during and after an event.

Review maximum rates of rise and fall for Lake Eildon releases

Whilst analysis shows that the proposal for supplementing tributary inflows with releases from Lake Eildon is feasible under current Lake Eildon operating rules, the rate that flows can be increased (and decreased) to initiate flow events and in response to tributary flow fluctuations is limited by maximum rates of flow change rules.

The primary purpose of the rate of fall rules is to avoid damage to river banks through rapid changes in water level. If these rules can be relaxed, more rapid increases and decreases in flows downstream of Lake Eildon would be possible and the effectiveness of inflow supplementation actions would be improved. The current rules were established many years ago, and are believed to be quite conservative. The MDBA has similar rules for rates of reduction in flows below Lake Hume, and has recently begun trials to relax these rules.

As part of implementation of this project, the current Lake Eildon rules would be reviewed and expert geomorphological advice sought on suitable rates of flow change.

7.6 Staff training

The project's proposed implementation phase includes the preparation and delivery of an extensive staff training program to build the necessary capability to apply the procedures and tools described above to deliver effective watering events.

Training would focus primarily on GMW river operations staff, but also include environmental water management staff from the CMA and the Victorian and Commonwealth Environmental Water Holders as necessary to ensure a shared understanding of roles, responsibilities and communication and collaboration procedures required to deliver an event.

In additional to structured "classroom" learning, it is also proposed that the training program would include a range of hands-on activities, particularly simulated events, including:

a. *Shadow operations in real time during natural events*. Staff would monitor the system and make the decisions that would be required to make supplementary releases for the environment. Whilst releases would not be made, the proposed decisions would be tracked and simulated on modelling tools, and the flows that would have been generated in the lower Goulburn can be estimated and compared to the intended flow objectives for the shadow event.
b. *Simulated desktop operations*. Data from historic events that would have been suitable for supplementary environmental releases can be collected and fed to system operators to allow them to simulate the planning and decision making actions required in an event. The desk top simulation enables lengthy events to be replicated in a compressed timeframe (e.g. hourly rainfall data can be provided every 5 minutes and travel times for flows can be compressed).

7.7 Other required policy or operational changes

As noted above, a range of amendments would be required to river operating procedures and processes in the Goulburn River system. No other amendments to state legislation or policy are anticipated. This includes no requirements for formal amendments to state water sharing frameworks, as the operating procedural changes proposed all fall within the provisions of current Bulk Entitlement orders. Implementation of the outcomes of the proposed review of the maximum rates of rise and fall for Lake Eildon releases would require Ministerial approval for any changes to this operating rule, but this does not require any amendment to the Bulk Entitlement Order.

It is not expected that the changes to operating arrangements in the Goulburn system outlined above would result in any requirement to amend the *Murray-Darling Basin Agreement 2008*, or operating rules that exist under this Agreement.

The Loch Garry Flood Protection scheme is located downstream of Shepparton and consists of a large regulating structure and associated levees that can be used prevent frequent nuisance flooding escaping from the Goulburn River and inundating properties. In larger flood events, the regulator is opened to allow water to flow out of the Goulburn River and along Bunbartha Creek. It should be noted that the planned peak flow (30,000 ML/day) is below the trigger level for operation of the Loch Garry regulator (above 40,000 ML/day). Consequently, it is not proposed to modify the current Loch Garry operating arrangements nor to open the regulator during managed events.

The process that would be required to settle agreements with affected landholders should this project proceed has been captured elsewhere in this business case (refer section 9.3). This section deals with matters that are specifically relevant to state policy and legislation, and any associated inter-jurisdictional agreements.

Matters related to the regulatory approvals that would be necessary for the implementation of this project are also discussed elsewhere in this business case.

8. Third Party impacts and mitigation measures

8.1 Refinement of risk assessment for third party impacts

The risk assessment carried out for this business case provides a high level assessment of potential third party impacts (Tranter, 2015). The project is still at the feasibility stage therefore the risk assessment should be refined if the project is further developed.

This would require:

- Reevaluation of the project's risks as new information becomes available, particularly specific impacts to individual properties (section 11.1)
- continued refinement of the hydraulic model and topographical surveys to improve accuracy of inundation footprints, particularly between Seymour and Goulburn Weir and around the junction with the River Murray (section 11.1)
- improved understanding of broader social and economic impacts through ongoing consultation and assessment with the community and other project stakeholders (section 12).

8.2 Overview

The harnessing of Goulburn River water resources and the subsequent operating rules have provided a greater level of flood protection to local communities. This has allowed the development of the floodplain for farming, residential and other business purposes.

The proposal to change the operating rules under the Goulburn Constraints Measure therefore alters the current level of flood protection experienced by the community. The potential third party impacts of this project have been considered using hydraulic modelling to understand the environmental, economic and social assets potentially affected (Appendix 1).

The focus of this assessment is on impacts in Victoria. Increased Goulburn flows would also create overbank flows in New South Wales (NSW), both north east of the Goulburn-Murray confluence and further downstream. This area is part of the Yarrawonga to Wakool key focus area and it is assumed that inundation in these areas is being considered in detail in the business case for that constraint management project.

This section focusses on third party (social and economic) impacts and have been considered at two levels:

- **Identified impacts from planned inundation**: the negative flood related impacts as a result of the project
- **Other potential impacts of the project**: adverse impacts during the project's construction or operational phase.

The assessment of third party impacts has been informed by a range of technical investigations and community consultation, as well as an AS/NZS ISO 31000:2009 compliant risk assessment process (Appendix 6). Environmental and project delivery risks considered through this process are described in sections 5.2 and 14.2 respectively.

Collectively, these assessments have contributed to the view presented by this business case that the proposed mitigation measures would be effective in managing the identified and potential impacts of the project. While they may be effective, challenges are anticipated in achieving their implementation, posing a key risk to the project delivery (section 14.2).

8.3 Overview of identified impacts from planned inundation

Assessment of impacts

The proposed mitigation measures put forward by this business case, represent a balance between the benefits that can be achieved from higher flows against the cost of achieving them based on an evaluation of identified impacts from planned inundation (section 9).

Identified impacts from planned inundation have been informed by a number of key studies including:

- asset mapping and 2-D hydraulic modelling of the river and its floodplain to improve understanding of what river flows inundate what floodplain assets (Water Technology 2015a)
- hydrologic analysis and modelling to understand the behaviour of tributaries in producing flows and scope the potential for using reduced diversion from Waranga Basin and releases from Lake Eildon to top up these flows (Jacobs 2015a)
- a risk based assessment of the lower Goulburn levee system to understand the work required to improve the levees to an acceptable standard and any outlet structures requiring upgrades (Water Technology 2015, GMR Engineering, 2015 & 2015a)
- assessment of the potential impacts on public infrastructure e.g. public roads, bridges and town drainage by consulting with local government (AECOM, 2015)
- identification of the extent of specialist (higher value) businesses impacted by examining the impacts on a representative sample of businesses (Jacobs, 2015b).

Community consultation has been ongoing throughout the development of the MDBA Constraints Management Strategy and this business case (see section 12 for details), and has contributed important local knowledge to the project, such as confirming hydraulic modelling outputs. Assessment of the specific impacts to more traditional farming businesses has not been undertaken due to time limitations but has been looked at in aggregate. However, understanding of the potential impacts has been improved by the refinement of inundation footprints with more accurate hydraulic modelling. This has allowed cost estimates for mitigation measures to be refined (GHD 2015) and would be an important element of the further investigations (section 9.5) should the project proceed.

Third party impacts presented in this section are based on the **maximum identified impact** (i.e. the risk management buffer of 15,000 ML/d at Alexandra and 40,000 ML/d at Shepparton). High level public and private impacts are shown in Table 8-1 and Table 8-2 respectively. The tables present the direct project impacts (hectares of inundation) and options to limit or offset the impacts on current economic and social use of the floodplain.

Table 8-1: High level third party public impacts and mitigation measures

Stakeholder	Description of potential impact	Mitigation Options
Land managers including traditional owners	▪ Damage to roads, crossings and other infrastructure ▪ Pest plant and animal invasion or spread ▪ Interruption to recreational and cultural floodplain activities ▪ Increased activity around notification of road closures and management of licence holders	▪ Upgrade of roads and infrastructure ▪ Compensation for increased maintenance costs
Local government	▪ Damage to roads and assets e.g. bridges ▪ Reduced performance of drainage infrastructure ▪ Increased activity around notification of road closures ▪ Inundation of public spaces and walking tracks ▪ Increased emergency management coordination activities	▪ Upgrade of roads and infrastructure ▪ Levee upgrades ▪ Compensation for increased maintenance costs
General community	▪ Interruptions to access for recreational use ▪ Restrictions on leisure activities e.g. camping, fishing ▪ Restrictions on firewood collection ▪ Inconvenience and hazards due to road closures ▪ Loss of revenue for local businesses e.g. general stores ▪ Potential health impacts e.g. increased incidence of ross river virus	▪ Upgrade of roads and infrastructure ▪ Notification of planned flood events and road closures

Table 8-2: High level third party private impacts and mitigation measures

Stakeholder	Description of potential impact	Mitigation Options
Agricultural businesses	▪ Loss of productivity and revenue (linked to timing and duration) e.g. lost silage production, loss of pasture, reduced access to shelter areas for calving, increase in liver fluke ▪ Inundation of pumps ▪ Restriction of vehicle and stock movement ▪ Damage to levees, fences, roads and/or crossings ▪ Inundation of fixed structures (haysheds, silos) ▪ Drainage problems ▪ Spread of weeds ▪ Loss of time spent managing impacts ▪ Increased agistment costs or pressure on pasture in other areas of the farm ▪ Nutrient leaching (fertiliser input losses) ▪ Triggering Loch Garry regulator opening (section 7)	▪ Lower Goulburn levees and outlets ▪ Levees or easements ▪ Provision or upgrade of vehicle and stock crossings ▪ Upgrades to other farm infrastructure e.g. resiting of pumps ▪ Improved flood warning notifications
Specialist businesses	▪ Interruption to access required for day to day operations ▪ Potential loss of revenue ▪ Loss of time spent managing impacts	▪ Levees or easements ▪ Upgrade of roads and infrastructure ▪ Improved flood warning notifications
Residential properties	▪ Interruptions to access ▪ Inundation of buildings	▪ Levees ▪ Road raising ▪ Provision of vehicle crossings
Traditional Owners	▪ Damage to cultural heritage sites ▪ Disruption to native flora and fauna species e.g. fish kills from blackwater events	▪ Construction controls to protect cultural heritage sites ▪ Compensation for increased maintenance costs
Commercial public land operators	▪ Interruption to access required for day to day operations ▪ Potential loss of revenue	▪ Notification of planned flood events and road closures

Public impacts

Although flooding of public land is an intended outcome of this project there are potential adverse impacts associated with flooding of public roads and infrastructure, as described in Table 8-1 above.

The public impacts of the project are presented against the estimated inundation extents at the target flow (25,000 ML/day), peak flow (30,000 ML/day) and risk management buffer (40,000 ML/day) at Shepparton below.

Lower Goulburn

The majority (79%) of flooding in the lower Goulburn floodplain occurs on public land up to the peak flow rate of 30,000 ML/d at Shepparton (Figure 14). Above these flow rates, an increasing proportion of the inundation footprint occurs on privately owned land.

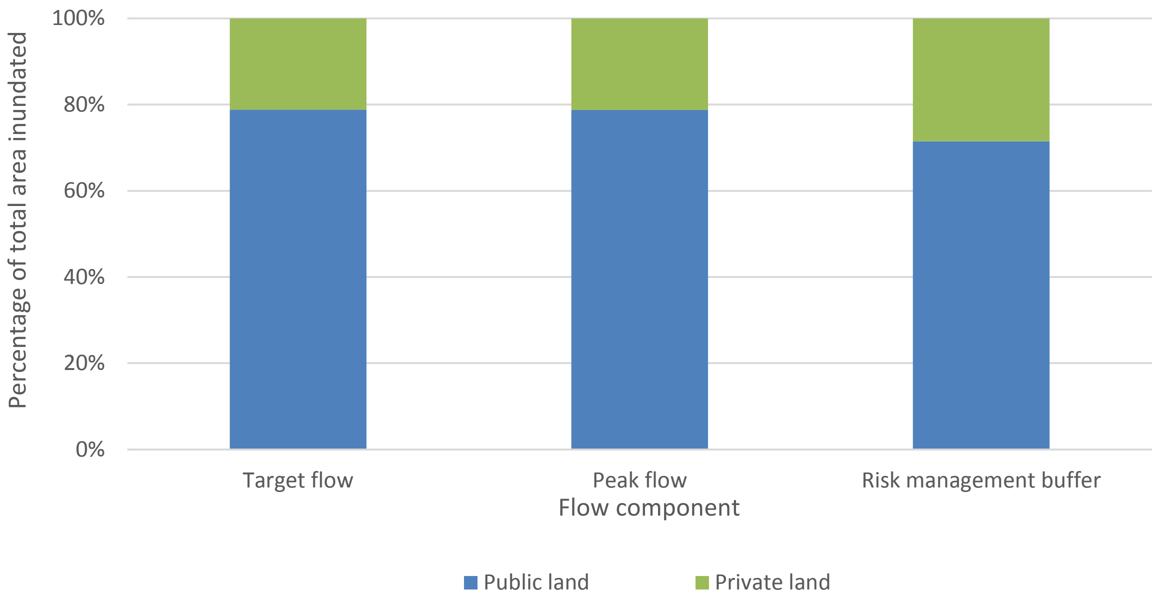

Figure 14: Proportion of private versus public land inundated for the lower Goulburn (Water Technology, 2016)

Figure 15 shows the total area of public land flooded in the lower Goulburn as:

- 8,130 ha at the target flow rate of 25,000 ML/day
- 9,750 ha at the peak flow rate of 30,000 ML/day, and
- a rapid increase to almost 13,000 ha at the 40,000 ML/day risk management buffer.

The greatest area of public land flooded is between Seven Creeks and McCoys Bridge representing over 50% of the total public land flooded area.

The impact of the project on inundation of public roads (excluding bush tracks) is presented in Figure 16 and shows a total of 7.5 km of road inundated at the target flow rate of 25,000 ML/day, with the length progressively increasing with higher flow.

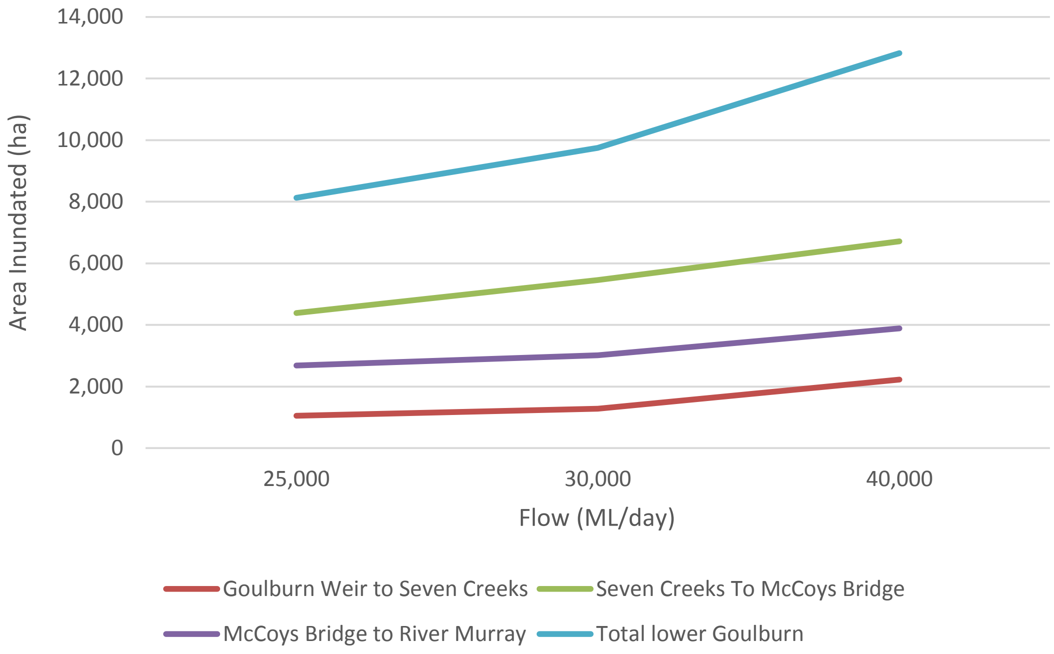

Figure 15: Extent of public land inundation on the lower Goulburn floodplain (Water Technology, 2016)

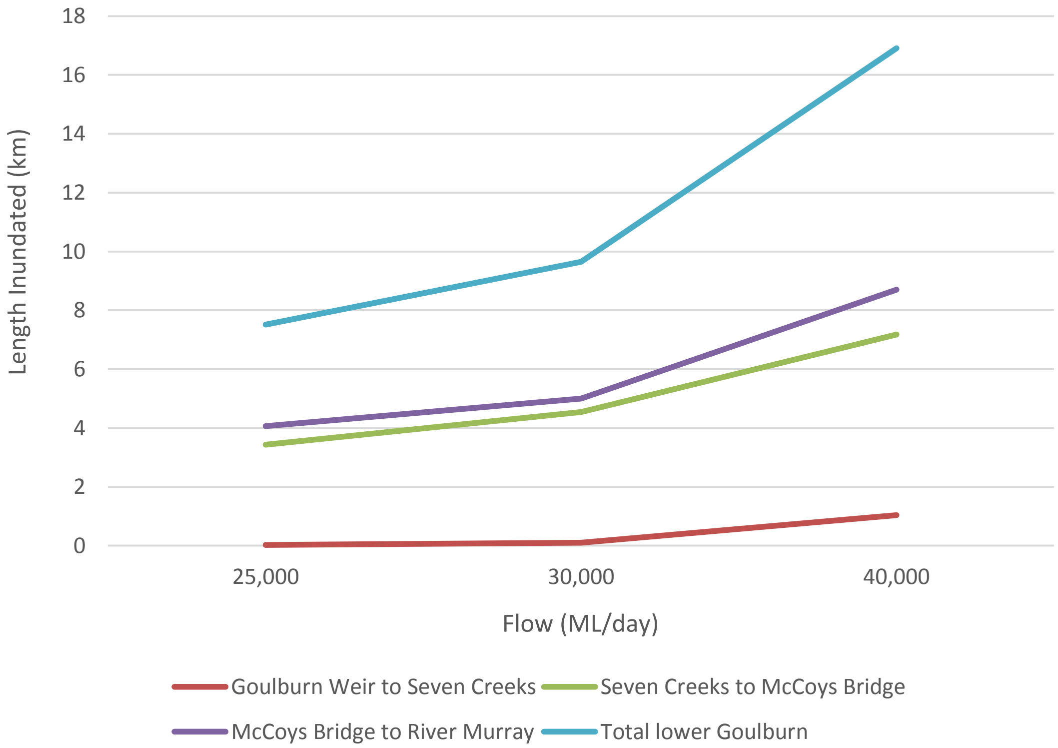

Figure 16: Length of public roads inundated on the lower Goulburn floodplain (Water Technology, 2016)

Consultants (AECOM, 2015) were engaged during the feasibility stage to investigate the potential public infrastructure works needed to mitigate the impacts of higher flows and the cost of implementing these actions. A key element of this work included consultation with the six impacted local shires. GBCMA consulted directly with Parks Victoria and Goulburn Valley Water.

Public assets considered as part of this process included roads (sealed, unsealed and forest tracks), walking tracks, bridges, culverts, fords and landscaped areas. The proposed peak flow of 30,000 ML/day sits at the lower end of the minor flood level and most public infrastructure has been designed to withstand higher levels of flooding, limiting the extent of mitigation activities required.

Key mitigation activities identified by AECOM (2015) as a result include:

- upgrade of isolated property access roads
- works at one bridge location
- agreement with councils regarding cost recovery for increased flood preparation activities and maintenance costs.

Consultation with Parks Victoria and Goulburn Valley Water has confirmed there are unlikely to be any significant increase in maintenance costs due to this project.

The anticipated mitigation activities described form the basis of the cost estimates presented in section 11.1 and would be further refined through the ongoing stages of the project.

Mid Goulburn

For the purposes of this section, the mid Goulburn is discussed as two reaches (Lake Eildon to Yea and Yea to the Goulburn Weir) due to the different risk management buffers set for Alexandra and Seymour.

It is known the hydraulic model is currently overestimating flooding downstream of Seymour (Water Technology, 2016), therefore these numbers may be reduced as further accuracy in the model is achieved through the ongoing stages of the project.

Flooding is restricted to small areas of public land in the most upstream reach of the mid Goulburn (Lake Eildon to Yea). An estimated 650 ha is flooded at flows of 9,000 ML/day up to an estimated maximum of 885 ha at flows within the buffer of 15,000 ML/day. There is minimal impacts on public roads, from a negligible impact at 9,000 ML/day to 275m at 15,000 ML/day.

Modelling results at the 35,000 ML/day buffer from Yea to the Goulburn Weir are currently unavailable, therefore anticipated flooding in the mid Goulburn is guided by the results for the 30,000 ML/day and 40,000 ML/day model runs. The estimated area of public land inundation for this reach is between 1,300 ha and 1,560 ha for flows of 30,000 ML/day and 40,000 ML/day respectively. Similarly, the length of public road inundated is estimated at 1-1.6 km.

Access to one specialist business in the mid Goulburn is affected by public road inundation.

Private impacts

Lower Goulburn

As discussed in section 2.1, the proposed operating strategy aims to manage flows within the peak flow rate (30,000 ML/day or less). However, due to uncertainty in predicting tributary inflows, risk management buffers ensure the project has planned and accounted for potential third party risks should higher than anticipated flows occur.

Figure 17 shows the anticipated area of private land inundation in the lower Goulburn is:

- almost 2,200 ha at the target flow rate (25,000 ML/day)
- 2,600 ha at the peak flow rate of 30,000 ML/day, and
- 5,120 ha at the risk management buffer.

The approach used by this business case is to describe the third party impacts based on risk management buffer of 40,000 ML/day flow rate. On this basis, an estimated 257 titles (GHD, 2014a) across 5,120 ha fall within the risk management buffer.

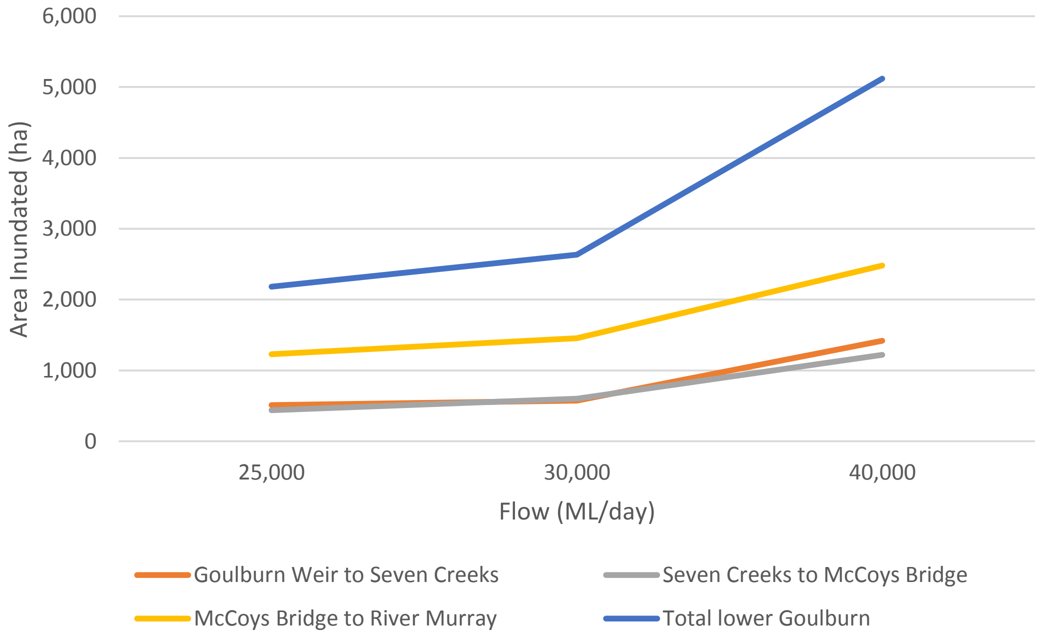

Figure 17: Extent of private land inundation on the lower Goulburn floodplain (Water Technology, 2016)

Overall, approximately 45% of the private land inundated in the lower Goulburn at 30,000 ML/day occurs in the first two reaches (between the Goulburn Weir and McCoys Bridge), with the remaining 55% (1,450 ha) in the most downstream reach between McCoys Bridge and the River Murray confluence. The area inundated increases rapidly above the peak flow rate if the risk management buffer is activated (Figure 17).

Inundated land use is predominantly dryland broadacre crops and pasture, and forestry, with a small amount of intensive agriculture. Mitigations are required to offset the impact of inundation on private land described in Table 8-2 and include:

- easements agreements across 257 titles
- capital works on private infrastructure (especially bridges and crossings).

Further detail on the proposed mitigations are provided in section 9.

There are large areas of remnant native vegetation on private land within the lower Goulburn floodplain. At the risk management buffer of 40,000 ML/day an estimated 1,500 ha of remnant vegetation on private land would be inundated when natural flood inundation occurs (Figure 18).

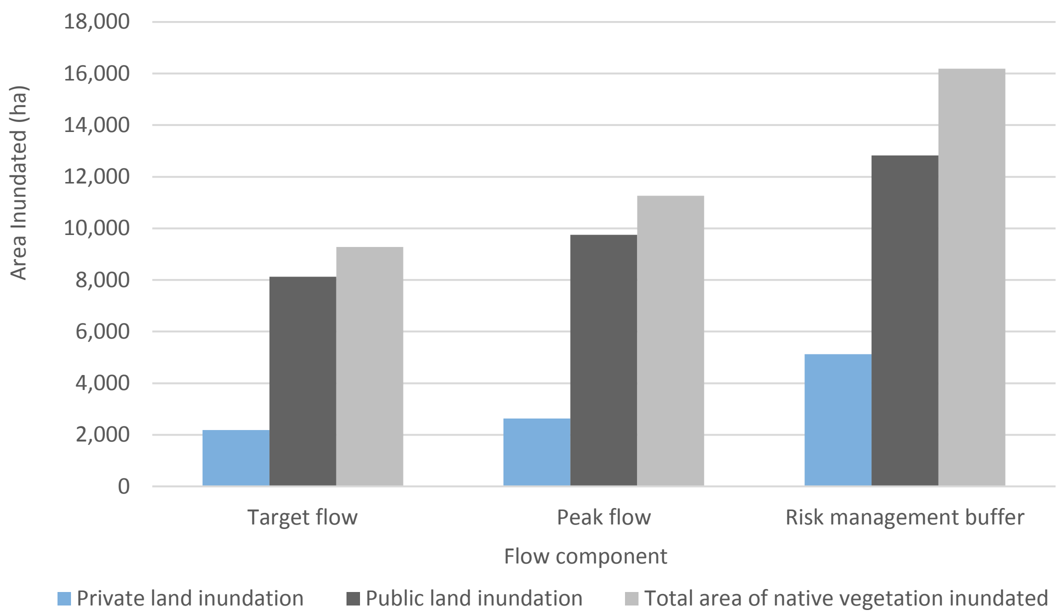

Figure 18: Inundation of native remnant vegetation on private land, estimated as the difference between total and public land inundation (Water Technology, 2016)

In the lower Goulburn, the number of buildings located on land inundated is quite low (five) at 25,000 ML/day, increasing to 13 within the risk management buffer. Additional work is required to confirm how or if these buildings are currently used, potential adverse impacts created by the project and what mitigations may be required. Issues relating to access to houses as a result of road inundation, are dealt with in section 8.3 above.

Analysis of specialist agricultural businesses and their area of plantings shows only two susceptible to some level of flooding, however neither are affected by flows of 40,000 ML/day and are therefore not impacted by the project.

There are several tourism facilities located along the lower Goulburn floodplain, of which two may be affected by the range of flows proposed. One of these starts to get inundated at 40,000 ML/day and is unlikely to be impacted by the project, while the other is 30% covered at 30,000 ML/day, increasing in area at higher flows.

Mid Goulburn

At the target flow of 10,000 ML/day flooding between Lake Eildon and Yea is generally confined within flood-runners, resulting in a comparatively small area of private land inundated (<150 ha) (Figure 19). The primary impact of this flooding is reduced access. As flows rise above 12,500 ML/day, water increasingly spreads out onto the floodplain inundating 545 ha across a number of properties (114) at the buffer of 15,000 ML/day.

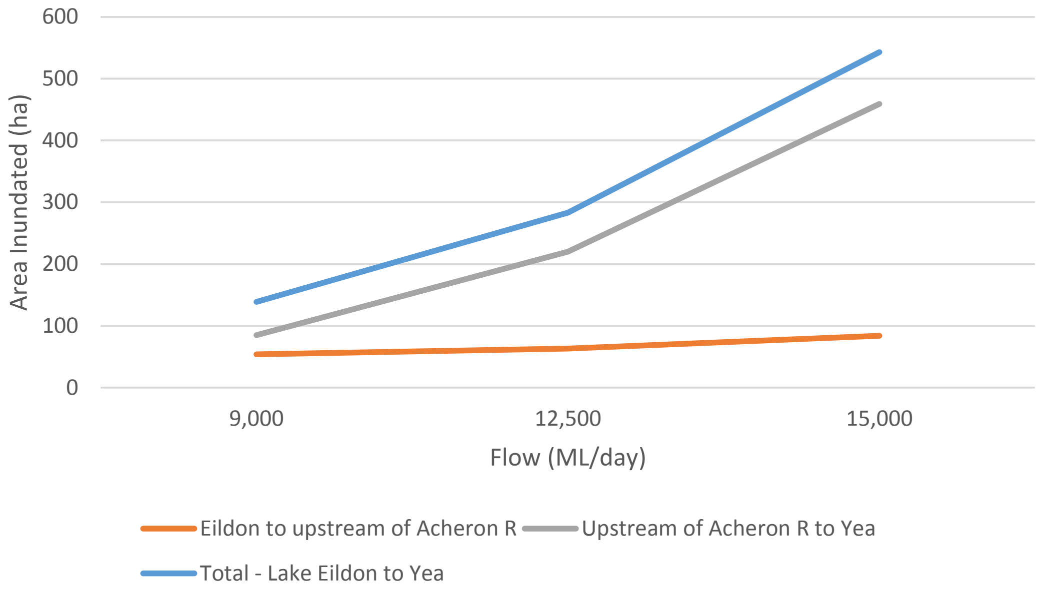

Figure 19: Extent of private land inundation between Lake Eildon and Yea (Water Technology, 2016)

Greater inundation impacts are observed downstream of Yea, with an estimated 3,130 ha[5] of inundation between Yea and the Goulburn Weir at flows within the 35,000 ML/day buffer (Figure 20). Current estimates are that 191 properties would be affected. It is known the hydraulic model is currently overestimating flooding downstream of Seymour (Water Technology, 2016) therefore these numbers may be reduced as further accuracy in the model is achieved through the next stages of the project, should it proceed.

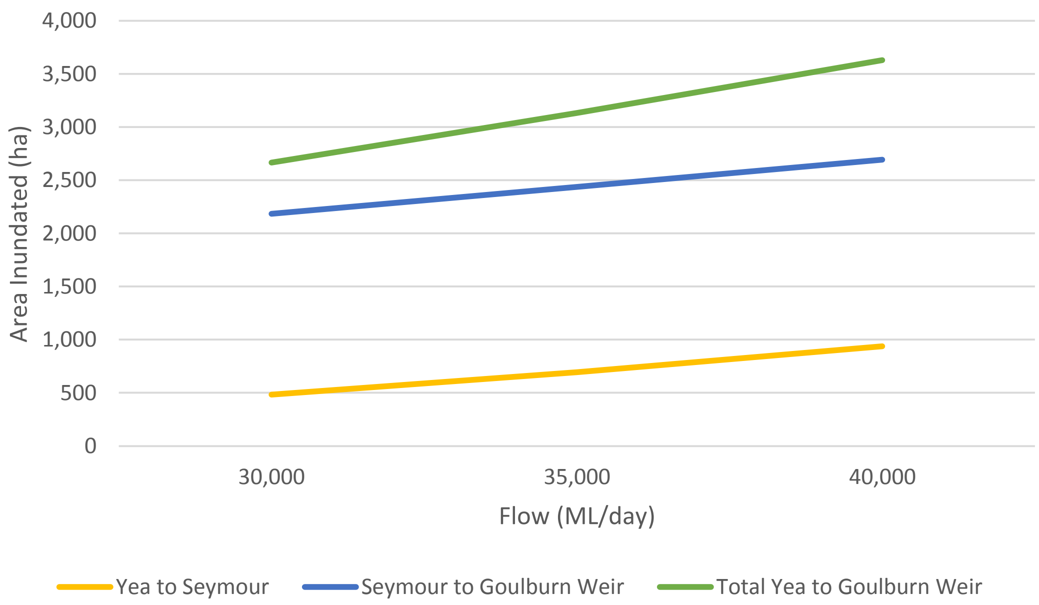

Figure 20: Extent of private land inundation between Yea and Goulburn Weir (Water Technology, 2016)

[5] Interpolated value based on the 30,000 ML/day and 35,000 ML/day model runs

Similar to the lower Goulburn, the bulk of inundation in the mid Goulburn is farmland inundation predominantly of dryland broadacre crops and pasture, and forestry. Analysis of specialist agricultural businesses shows only one of these affected at flows within the buffer and this is restricted to a small portion (2%) of land on that property. More detailed investigation is needed to determine the impacts on that property. No other inundation of vineyards, green tea, orchards or turf farms occurs at the flows being considered.

In addition to the lower Goulburn, mitigations to offset private land impacts would include:

- easements agreements across up to 305 properties
- capital works on private infrastructure (especially bridges and crossings).

A further three (non-agricultural) specialist businesses are affected to varying degrees at flows within the buffer. This flooding ranges from negligible at two of the sites, to an approximately 30% at the buffer flow for the remaining site. As for the lower Goulburn, targeted mitigation activities are likely to be required for this site and include a combination of infrastructure and easement options.

No buildings are affected at the flows being considered between Lake Eildon and Yea. Downstream of Yea, a total of 15 buildings may be impacted. Thirteen of these buildings are located downstream of Seymour therefore this number may reduce as refinements to the hydraulic model in this section of river occur. Again, further work is needed to confirm the type and use of these buildings in order to better understand the impacts.

Levees

Lower Goulburn

In the lower Goulburn, existing levees prevent further third party impacts outside the levees. Specific mitigation actions have been identified to ensure these levees are fit for purpose to contain water up to the buffer flow of 40,000 ML/day.

The lower Goulburn levees confine flows within the 156 km stretch of river between Shepparton and the River Murray, as shown in Figure 21. The 147 km of levees were constructed over many years, with 72 km located on private land (Water Technology, 2013).

Generally, the levees provide a 1 in 5 year level of flood protection, equivalent to a flow of around 70,000 ML/day at Shepparton (Personal communication, Geoff Earl GBCMA, 27 October 2015). However, with little or no regular maintenance, many of the levees have fallen into a less than satisfactory condition and offer differing standards of flood protection along the length of the lower Goulburn River (Water Technology, 2013).

The current condition of these levees is a key risk and the project requires mitigation activities to fix crest levels that are too low and weak spots at risk of being breached. To achieve this, the project also needs to obtain rights to fix and maintain the levees.

An investigation into the works needed to ensure the adequacy of the levee system to contain flows of up to 40,000 ML/day was carried out during the development of this business case. Observed points of weakness were mapped (Water Technology, 2016; Water Technology, 2016; Water Technology, 2016), including erosion, or impacts of human activities such as tracks and pipes through or over the levee, or biological impacts such as tree regeneration and rabbit burrows.

Key findings were:

- crest height needs to be raised along 0.4 km of levee at one site
- there are 670 points of weakness and 7.7 km of lines of weakness that need to be rectified

- levee replacement is needed along 2.3 km at four sites
- levee realignment is needed along 5.1 km at five sites
- rights to access levees (via land rights or easements) are needed to upgrade and maintain the levees.

In addition, confirming an ongoing process for the maintenance and inspection of these levees is required to ensure third party impacts are managed into the future (section 9).

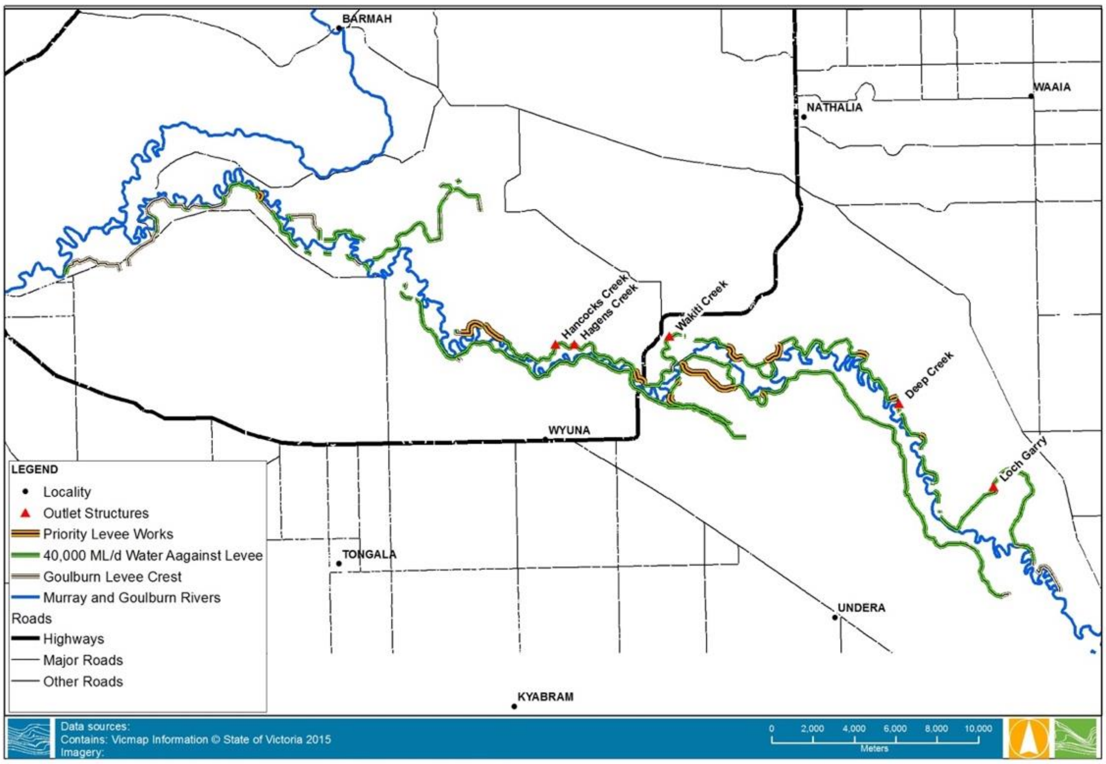

Figure 21: Lower Goulburn levee network showing the location of the key flow control structures (Water Technology, 2016b)

A number of outlets are located within the levee that allow for controlled flow releases during higher flow periods. Structures that become engaged at flows of 40,000 ML/day include the Hagens, Wakiti and Hancocks outlets (Personal communication, Geoff Earl GBCMA, 27 October 2015), releasing water to the Wakati Creek system. The feasibility investigation has evaluated options for installing gates on these regulators and upgrading the gates on Deep Creek to prevent water passing through them during environmental flow releases, and of the structural integrity of the regulators for this installation (GMR Engineering Services, 2015; GMR Engineering Services, 2015a).

The proposed works at these outlets structures is described in section 9.

8.4 Residual risks

A range of mitigation measures have been developed to prevent unacceptable impacts on private and public assets. These measures include upgrading and refurbishment of levees, raising access routes, negotiating legal rights to inundate land, and the extent of the potential impacts (see section 8.3 for details).

Any major project carries with it the possibility that unexpected or unplanned events may occur, with associated impacts to third parties during the project's construction and operational phases.

These unplanned events are usually referred to as risks, and whilst they are unplanned, they are foreseeable.

A high level risk assessment was undertaken for the project, in accordance with the provisions of AS/NZS ISO 31000:2009 (Appendix 7). The outcomes of this assessment process are documented in the *Goulburn Constraints Management Project: Risk Management Strategy* (Tranter, 2015) and takes into account the third party project risks associated with the project's construction and operational stages.

As discussed previously, the assessment provides a preliminary basis for prioritising mitigation strategies and measures based on currently available information. A more detailed risk assessment would be carried out should the Basin ministers decide to proceed further with the project.

The full suite of risks considered by the assessment process is documented in Tranter (2015) and a summary of pre-treatment risks with a rating of significant or higher is provided in Appendix 8. There are a number of significant risks that need to be managed to avoid or minimise third party impacts, and Appendix 8 sets out the mitigation actions identified to address these risks. The majority of these risks can be effectively mitigated through identified measures.

Most of the risks identified can be managed through the implementation of control actions. There are two remaining priority risks that cannot be adequately managed with identified controls. These are discussed below and would need to be addressed in the subsequent stages of this project, should it proceed.

Inability to accurately predict tributary inflows:

A key risk for the project is supplementing tributary inflows to meet the planned flow targets at Shepparton. There are two aspects to this issue.

Supplementing tributary inflows with releases from Lake Eildon has been assessed as a **significant risk** for the project. If the expected inflows from tributaries cannot be predicted with sufficient accuracy, then there is potential for releases to result in flows higher or lower than the targeted rates, which may result in unintended flooding of private land with potentially large financial consequences, or failure to achieve the intended environmental outcomes. The second and closely related aspect of this risk is that once a release event has been initiated, if unexpected rainfall events occur, natural tributary inflows may increase, with potential for unplanned flooding to occur.

The risk mitigation strategy has five key elements:

i. Developing expanded data collection networks and improved tools to support accurate forecasting of tributary inflows and improved planning of river flow behaviour. This would improve understanding of the expected tributary inflows and how these flows and releases from Lake Eildon would travel through the system in time and space to contain flows within planned limits. These arrangements are described in more detail in section 7, but would include:
    - Expansion of the rainfall and streamflow monitoring network in the mid Goulburn catchment
    - Further development of existing streamflow forecasting services by the BoM
    - Development of automated data interfaces between GMW and BoM system to effective share and manage forecast data which would drive modelling and decision support tools.
    - Development of improved river management tools and procedures by the system operator, GMW

ii. Provision of substantial buffer allowances on infrastructure to provide additional freeboard above the targeted maximum environmental flows.
iii. Reduction of Lake Eildon releases and diversion of Lake Eildon releases to Waranga Basin if downstream tributary inflows increase unexpectedly during an event, and opening of Hancocks, Hagens and Wakati regulators to allow passage of the subsequent natural floodwaters through the lower Goulburn levees.
iv. Development of revised operating procedures to formalise these mitigation actions together into clearly articulated processes for the operational management, monitoring and co-ordination of events.
v. Phased implementation of the watering program is proposed so that events are targeted at the lower end of the planned range initially to monitor system performance and to provide data for adaptive management of operational planning tools and procedures.

This mitigation strategy is ultimately expected to be effective in managing the likelihood of unplanned flood of private land, however, given that some of the streamflow forecasting and river operational management tools have not been fully scoped or designed, it is considered prudent to continue to rate this as a significant risk at this time.

Lack of community support:

Lack of support from affected stakeholders and communities is also considered to be a key project risk. The primary control is an extensive and ongoing communications and engagement strategy that aims to fully inform stakeholders and appropriately address all issues that are identified. This communications and engagement strategy is detailed in section 12, and is included in the costings for the project. Given the complex and potentially changing nature of community concerns, the engagement strategy would need to closely monitor these issues and be frequently revised and updated to ensure it is able to effectively engage with and address community concerns.

Two other issues are worthy of noting.

The initial risk assessment also identified a risk around uncertainty in regard to roles, responsibilities and liabilities for aspects of the project. As noted in section 11.5, Victoria currently has agreed arrangements in place through the Basin Senior Officials Group (BSOG) to resolve asset ownership arrangements for its nine works-based supply measures. This process would inform any arrangements that are finalised for this project.

The assessment of risks and issues around physical performance of the river system and forecasting of inflows and likely flows that can be generated by supplementing inflows has been based on analysis of historic system performance over the last 55 years. This means that there is no explicit consideration of how climate change may change rainfall and river flows in future. It is likely that climate change may affect the frequency, magnitude and seasonality of future inflow events.

This project aims to enable the supplementation of tributary inflows, and it would still be able to achieve those outcomes in the future; however the scale and frequency of achievement of these benefits may change (either positively or negatively) as climate change affects water systems. It is proposed that water system behaviour would be regularly monitored and reviewed in future to understand if the nature and behaviour of high flow events is changing as a result of climate change. The operating procedures for this scheme would be updated as necessary to respond to any changes identified.

9. Technical feasibility and fitness for purpose

A range of actions have been identified in this business case to enable the delivery of small overbank flows (25,000 ML/day for up to five days) in the lower Goulburn River downstream of Shepparton. These actions can be broadly categorised as those needed to deliver the increased flows and those required to mitigate unacceptable third party impacts associated with the delivery of these increased flows.

On the basis of the studies and assessments undertaken to date, these actions are considered technically feasible and are expected to effectively achieve the project's identified objectives. Should Basin ministers decide to proceed with the project, further investigations, analysis and development of engineering designs would be required to confirm the final project for implementation. These activities are discussed in section 9.5 (Further work required), section 11 (Costs) and section 14.3 (Implementation plan).

9.1 Proposed actions to deliver increased flows

The key action required to deliver overbank flows in the lower Goulburn is supplementing unregulated tributary inflows originating in the mid Goulburn and lower Goulburn reaches via ceasing diversions to Waranga Basin and passing these flows over Goulburn Weir, and additional releases from Lake Eildon (refer to section 7 for further detail on proposed operations).

A hydrological analysis of historical daily flow data over the period 1960 – 2014 was undertaken using river flow routing techniques, to test the feasibility of these mechanisms to supplement tributary inflows and meet flow targets (Table 7-1). This analysis also assessed the extent to which flows could be supplemented and the frequency of events that could be created that met the flow target (25,000 ML/day for four to five days). The analysis highlighted the need to use rainfall and streamflow forecasts to decide whether to release from Lake Eildon, rather than relying on observed streamflows to trigger releases. The analysis also confirmed that it would be possible to mitigate some higher than desirable flows once supplementary release had been initiated, by recommencing diversions to Waranga Basin and reducing Lake Eildon releases.

Overall, the analysis provides "proof of concept" that these mechanisms provide a feasible means to meet flow targets. Limitations and aspects for further development, particularly regarding improved forecasting ability, have also been identified. Key limitations include:

- Use of daily timestep data does not allow detailed analysis of instantaneous flow peaks, which may be greater than average daily flows
- Losses are not explicitly allowed for and are "lumped in" as part of the net contribution to flow from ungauged catchments. Changes in loss behaviour for events which move from in-channel to overbank have not been considered.

Other actions that would be necessary to support the release of supplementary environmental flows include:

- additional rainfall and streamflow monitoring sites in the mid Goulburn
- expanded coverage of the BoM streamflow forecasting services in the Goulburn catchment.

Development and implementation of eWater Source modelling tools to support real time operational decision making on water systems management is also proposed. This is an important action, as it would provide the capability to estimate tributary inflows and to develop effective release plans to deliver the flows needed to meet the lower Goulburn target flowrates. This tool would also be used to estimate tributary inflows during events and reduce supplementary environmental releases in order to avoid unacceptable impacts from higher than planned flow rates.

The streamflow forecasting product recently launched by BoM has been used by the MDBA to assess unregulated flows from tributaries downstream of Lake Hume. BoM is prepared to expand the coverage of this service in the Goulburn. The accuracy of forecasts is particularly important for flow management and would be improved in the future through the use of probabilistic forecasts. The accuracy of forecasts would need to be assessed further during implementation of this project.

The eWater Source modelling tools have been developed through an extensive research and development program, and are being adopted as the standard national hydrologic modelling platform. Source has not been deployed in an operational mode in Victoria, and there would be a considerable amount of work required to implement and calibrate this tool to the level of accuracy required for this project. DELWP is currently implementing Source as their primary hydrologic simulation modelling tool. It is expected that this work would provide a strong base to develop the operational river management capabilities. The MDBA is also moving its simulation modelling to the Source platform and intends to implement the operational management capabilities, which would help build a wider community of practice to support development of these tools in both jurisdictions.

9.2 Principles and process for determining mitigation options

When determining the specific mitigation options to address each impact, this business case has assumed that the process should start with a least cost option, but consider using a higher cost option in order to ensure that the measure effectively and appropriately mitigates the impact, including:

i. that the affected parties are not worse off
ii. that any safety considerations (such as critical public access routes) are not compromised
iii. that measures would help communities adapt to a changed flow regime
iv. arrangements are enduring
v. that the transaction costs to implement the mitigation actions are reasonable, and
vi. other practical and policy considerations have been considered, particularly as they relate to working with stakeholders on just terms and avoid creating perverse incentives.

Recognising the above principles, in assessing the appropriate mitigation measures to address interrupted access to private agricultural land, and to address impacts on specialist activities, two distinct options have been considered:

i. a “least cost” option, in which it is assumed that easements would be the preferred mitigation option, and that infrastructure works (e.g. upgrades to private crossings, or infrastructure to protect specialist businesses) would only be implemented where it is more cost effective to do so than to purchase easements;
ii. an “upper bound” option, in which it is assumed that more significant infrastructure works would be required.

Note that in the context of this business case, mitigation options were considered at a regional rather than a property-by-property scale. If this business case were to be implemented, further assessment would be required at a property-by-property level, in consultation with landholders.

9.3 Actions required to mitigate third party impacts

Section 8 provides details of the expected extent of inundation within the risk management buffer (40,000 ML/day) and the proposed mitigation actions to avoid potential impacts on public and private assets, to improve forecasting tools and real-time flow management, and protect cultural heritage sites. The proposed activities are listed in Table 9-1 and further detail is provided below.

Table 9-1: Summary of mitigation actions

Activities to mitigate impacts on private land and assets	Activities to mitigate impacts on public land and assets	General mitigation activities required across the project area
▪ Priority works on lower Goulburn levee system, including upgrading existing outlets ▪ Acquisition of easements over private land, covering rights to flood land and rights to enable access to levees for operations and maintenance activities. ▪ Capital works on private infrastructure (especially bridges and crossings) to maintain access ▪ Targeted works and acquisition of easements to address impacts on specialist businesses	▪ Additional operational response (e.g. road closures) and reinstatement/repair of public infrastructure subjected to more frequent inundation (e.g. roads, bridges and parklands). ▪ Capital works to upgrade public road access to isolated properties ▪ Capital works to upgrade a public road bridge at Stewarts Road	▪ Continuation of existing practices to notify adjacent landholders and owners of assets near the river in relation to significant planned changes in releases that may impact on assets or livestock.

Lower Goulburn Levees

There is an extensive network of levees in the lower Goulburn protecting private agricultural land (refer section 8.3 for further detail). The wetlands and vegetation areas targeted for inundation under this project are all on the river side of this levee system, however there is also some private land within this area. The levees are in variable condition, are located on a mix of private and public land, and there is no formal maintenance program.

There is a reasonable understanding of the work required to improve the levees to an acceptable standard. This work would not provide increased levels of protection from natural flooding but would provide more reliable protection at current levels (including the flows targeted by this project). To enable legal access to repair, operate and maintain the levees over the long term, agreements with private landholders to either purchase land or to establish easements would be required.

Works are also needed on three existing outlets in the levees that currently release flows during natural flood events. These outlets would need to be upgraded or replaced and fitted with the appropriate operating mechanisms (to be confirmed in subsequent stages of the project).

It should be noted that all of the works proposed for levee upgrades and upgrades to outlet structures are widely applied, well understood, standard engineering works. There is a significant body of experience and expertise available to support their implementation.

Flood easements

Acquisition of flood easements is proposed to provide the legal right to pass managed flows over private land. The cost of easements would reflect the long-term impact of proposed overbank flows. Easements would be negotiated with landholders through a voluntary process.

While there is a successful example of such a process (the acquisition of easements to allow managed flows of up to 25,000 ML/day in the Hume-Yarrawonga reach of the River Murray) and it is considered feasible, significant time and effort would be required to establish and manage effective relationships with affected landowners, gather detailed information relating to impacts on individual properties, agree and apply principles by which easements should be costed, and implement legal and other administrative arrangements.

It is the position of the Victorian Government there would no compulsory acquisition associated with the project. It is recognised that some stakeholders have expressed reluctance to participate in an easement process and is therefore identified as a key delivery risk (refer section 14.2). The key strategy to address this through an intensive consultation and engagement program (section 12.7) monitored by a Project Control Board with oversight for project delivery (section 14.1).

Capital works to maintain access to private land

Capital works on private infrastructure such as crossings and bridges have been proposed on the basis that they would be necessary for areas of land which would suffer from “interrupted access” caused by proposed higher flows, and/or maintain critical access. These are standard capital works and considered technically feasible, however they are part of the same voluntary process with landholders as easements. The time and effort required to implement such works needs to be recognised.

Specialist businesses

The mitigations for specialist businesses have been developed based on site visitation and detailed assessment of a selection of case studies. The final package of mitigation actions for these types of businesses would be developed on an individual basis, taking into account the cost of various alternative measures and the implications for each business. The measures identified are feasible, used elsewhere on the floodplain and costs proposed include provisions to allow for any additional works that may be required once detailed assessments and designs are completed.

Public infrastructure

Public infrastructure and assets including bridges, roads and parklands would also be subjected to more frequent inundation by this project. Reinstatement works on public infrastructure have been proposed in many cases rather than capital works as the latter would either be more expensive, and/or create undesirable impacts on the distribution of flood flows in larger natural events.

Agreements would need to be negotiated with individual councils or asset owners, through which those councils or asset owners would agree to a specified flow regime being allowed to affect their assets in perpetuity, and upfront funding would be provided in consideration for such an arrangement. Similar to the proposed mitigation activities for private land and infrastructure, it would take some time and effort to set up and manage arrangements with affected asset owners, agree on the likely scope and nature of the impacts, the basis by which costs would be met, and to develop and implement legal and other administrative arrangements.

Capital works are proposed on public roads to ensure continuity of access to a number of isolated rural properties. An upgrade of at least one public bridge (Stewarts Road) in the lower Goulburn is also required, as road closure would have unacceptable impacts given the lack of alternate non-flooded routes in the area.

All of the capital works (including levee upgrades) discussed above are widely applied, well understood, standard engineering works. There is a significant body of experience and expertise available to support their implementation. As noted below in Table 9-2, appropriate contingency allowances have been included in cost estimates and, if this project proceeds to the implementation phase, detailed site assessments would be conducted as part of the design process to reduce any uncertainties.

Table 9-2: Approach used for assessment of mitigation actions and implications for this business case.

Issue	Approach used for feasibility phase	Implications for this business case
Hydrology (what flows could be delivered, when, and how often)	Assumes 1 extra event every three years, on average, was used (equivalent to 3.3 extra events in 10 years).	Assumption is considered appropriate for purpose of defining an "upper bound" of potential additional environmental flows. (Subsequent hydrologic analysis shows events in 2.3 years in 10 for Goulburn events, confirming rule of thumb assumption is conservative).
Crossings (how many crossings are affected, their specifications, and what would need to be done to mitigate impacts)	Assumes all crossings which were found to intersect with a modelled inundation layer would be affected and would require capital works. This assumption was tested through ground-truthing with on-ground stakeholders, and through further analysis of the appropriate mix between crossings and other mitigation options (e.g. easements).	Takes into account estimate of how *many* crossings would actually require capital works. Note however that it was not possible to specifically *identify* individual crossings on private land; this would require detailed property-by-property consultations and would be undertaken in the implementation phase.
Roads (which roads are affected, their specifications, and what would need to be done to mitigate impacts)	Assumes that all roads (of certain classes) which were found to intersect with a modelled inundation layer would be affected. It was also assumed that the majority of these roads would require capital works. This assumption was subsequently tested through ground truthing with on-ground stakeholders and modified as appropriate.	Recognises that it many cases stakeholders have indicated that rather than major capital works, inundation of roads would generally be better addressed through a mechanism to allow for reinstatement activities.
Levees	Detailed survey of levee heights and points of weakness undertaken by ThinkSpatial. Upgrading works needs identified by Watertech study, which compared levee crest heights to water surface levels at target flows derived from hydraulic modelling studies.	Reliable assessment of the volumes of earthworks required on levees, and the extent of points of weakness that would need additional treatment. Technique applied and tested in Vic SDL projects. Use of suitable

Issue	Approach used for feasibility phase	Implications for this business case
	Upgrading works required identified using a risk based assessment methodology. Contingencies applied to reflect uncertainties	contingency allowances provides conservative estimate at a regional scale – to be further developed in implementation phase. Expert review has confirmed that the approach to levee risk assessment, treatment and costing is reasonable.
Outlet regulator structures	Concept design and cost report prepared by GMR Engineering Services. Included site inspection of existing structures and review of original design drawings to develop concept designs	Structural condition of existing assets established through visual inspection and costs for remedial works and addition of gates based on unit rates for similar recent works at TLM sites. Contingencies allow for uncertainty in current condition of structures etc. Accuracy of costing for each outlet regulator is considered suitable for feasibility level business case. Expert review confirms that the design is at a suitable level for a concept design.
Land use assumptions (what agricultural land uses would be affected)	ALUM land use classifications underpinned the modelling of easement costs. Land use classifications were refined through analysis of aerial photography.	Assumptions are as accurate as possible in the context of a regional level assessment. While there would be individual cases where there are inaccuracies, these inaccuracies are expected to balance each other out overall, and have an insignificant effect on the overall assessment.
Other assumptions relevant to easements (e.g. land values, gross margins, impacts on agriculture)	Assumptions were made drawing on publicly available datasets and were tested with local experts	Assumptions are as accurate as possible in the context of a regional level assessment. While assumptions would not necessarily be accurate at a micro (e.g. property) level, this is expected to have an insignificant effect on the overall assessment.
Specialist businesses (e.g. golf courses, caravan parks)	A selection of specialist businesses were identified as "case studies" and studied in detail, including through on-ground consultations.	Assessment of impacts, mitigation options and costs is considered appropriate for a regional level assessment. Further work would need to be undertaken during implementation phase to assess implications for

Issue	Approach used for feasibility phase	Implications for this business case
		individual businesses in detail.
Other impacts on landowners (e.g. pumps, fences) and options for mitigating those impacts.	Considered in some detail in the feasibility phase	Assessment of impacts, mitigation options and easement costs takes into account these impacts in a general sense. It was not possible to consider all impacts in detail, particularly at a micro (e.g. property) level. This would be undertaken in the implementation phase.
Interactions between different mitigation measures (e.g. easements vs infrastructure) and the appropriate mix of mitigation measures in different contexts.	Considered through a high-level cost-benefit assessment	Assessment takes into account these interactions in a regional context. Quantum of infrastructure mitigation options (e.g. private crossings) is therefore considered reasonable for feasibility purposes. It was not possible however to identify specific measures at a micro (e.g. property) level. This would be undertaken in the implementation phase.
Implementation and approvals processes	Considered in detail, including through assessment of what processes would be required in different jurisdictions	Assessment takes into account these processes in sufficient detail for feasibility purposes.
Spatial uncertainties associated with implementation of environmental flows, including: - Potential for flows to be higher than anticipated, for example if water releases are combined with natural events, and there is more rain than expected - Uncertainties in inundation modelling and mapping - Potential for channel cross sections to change over time	Considered through: - Allowance of "buffer" flows - Sensitivity analysis of key input parameters (e.g. areas of land affected, km of road affected) to take into account implications of spatial uncertainty for cost estimates - Contingency in cost estimates	Assessment recognises that there are uncertainties and takes them into account

9.4 Uncertainties

This is a feasibility level business case, and as such is based on available data combined with feasibility level investigations and analysis. The limitations of these studies are acknowledged, and the business case has therefore included “buffers” and/or contingencies into the proposed mitigation options and costs, to take into account these inherent risks or uncertainties. Key uncertainties included:

- actual frequency, timing and duration of environmental flows
- potential errors in inundation modelling (refer also to discussion in Appendix 1)
- economic assumptions
- appropriate balance between easement and infrastructure-based mitigation measures (noted in section above)
- costs of engineering works.

Key uncertainties, and how they were considered in the context of the proposed impacts and mitigation activities, are summarised in Table 9-3. The implications of this approach to uncertainties in relation to cost estimates are presented in Section 11. The costings for implementation of this proposal also include allowances for a range of further studies, data collection and other investigations to develop detailed designs and enable updating of the business case. These further investigations are designed to reduce the level of uncertainty associated with the project before moving into implementation of on-ground actions (refer Section 9.5 for further details).

Table 9-3: Mitigation measures assumed, and approach to taking into account uncertainties

Impact	Assumed mitigation activity	Key uncertainties	How uncertainties were considered
All impacts	All mitigation activities	Actual frequency, timing and duration of environmental flows	Hydrological modelling was deliberately designed to represent an upper limit to potential new flow regime. See discussion in section 6.
Inundation of agricultural land	Easements and/or levee upgrades	Accuracy of modelled flood footprint. Economic assumptions (e.g. land value, agistment costs, clean-up costs). Easement negotiation costs Actual condition of existing levees and extent of works required	Sensitivity testing of area of land assumed to be inundated Sensitivity testing around key economic parameters Applied technique developed and tested elsewhere for levee assessment and contingencies built into easement and levee cost estimates
Impacts on farm infrastructure			
Farm management issues			
Interrupted access to private agricultural land	Combination of easements and new or upgraded bridges and crossings	Area of land that would suffer from interrupted access (uncertainty in inundation modelling). Economic characteristics of the land (e.g. land value,	Sensitivity testing of area of land assumed to suffer from interrupted access Sensitivity testing around key economic parameters Range was considered, from a “least

Impact	Assumed mitigation activity	Key uncertainties	How uncertainties were considered
		agistment costs) Appropriate mix of easements vs infrastructure works.	cost" option (whereby infrastructure works would be proposed only to the extent they would be more cost effective than easements) to an "upper bound" higher option.
Damage to public infrastructure	Reinstatement activities	Quantum of infrastructure affected (uncertainty in inundation modelling) Frequency on which such reinstatement activities would be required	Sensitivity testing of quantum of key infrastructure items Sensitivity testing of hydrological assumptions (frequency of flow events) Contingencies built into infrastructure costs
	Capital works	Cost of engineering works required	Contingencies built into infrastructure costs
Impacts on specialist businesses	Combination of easements and infrastructure works	Appropriate mix of easements vs infrastructure works.	Range was considered, from a "least cost" option (whereby infrastructure works would be proposed only to the extent they would be more cost effective than easements) to an "upper bound" higher option. The upper bound has generally been adopted, unless this is significantly higher than the lower cost alternative – details to be resolved during implementation

9.5 Recommended further work if this measure were to progress to implementation

If this project proceeds to progress to implementation, it is recommended that further work be undertaken to develop a more refined assessment of third party impacts, mitigation options and costs. Key actions are summarised in Table 9-4. These matters are also discussed further as part of the implementation arrangements in section 14.

Table 9-4: Recommended further work required as part of implementation phase

Issue	Further work that would be required
Supplementary releases of water to enhance flows at Shepparton	Further develop and refine hydrologic modelling to address limitations identified as part of feasibility level study. Includes testing use of actual forecast data to trigger simulated release for Lake Eildon, extending modelling to sub-daily timestep and development of explicit loss relationships for overbank flow events. Installation of additional streamflow and rainfall monitoring sites in the mid Goulburn to provide data to improve understanding and forecasting of trib. flows and support development of operating arrangements/tools.
Private crossings	Property-by-property assessment required to identify specific private crossings that are affected, and specific mitigation measures required

Levees & outlet regulators	Preparation of detailed designs and costings, including geotechnical investigations and identification of suitable sources of borrow etc.
Public infrastructure (e.g. roads, crossings)	Need to negotiate agreements with asset managers (e.g. councils). This negotiation process would require further ground-truthing of impacts, mitigation measures and costs.
Acquisition of access easements or purchase of private land to enable levee works/maintenance	Need to negotiate agreements with landholders to establish access easements or land purchase. This would require further ground truthing of impacts, mitigation measures and costs, at a property level.
Easements (or other arrangements) over agricultural land	Need to negotiate agreements with landholders. This negotiation process would require further ground truthing of impacts, mitigation measures and costs, at a property level.
Specialist businesses	Need to negotiate agreements with business operators. This negotiation process would require further ground truthing of impacts, mitigation measures and costs, at a property level.
Inundation footprint	Knowledge of the inundation footprint would need to be further improved. This would need to involve: ▪ Developing new, and/or and refining existing inundation models ▪ On-ground assessment of actual flow events, involving local stakeholders (e.g. monitoring and measuring flows over specific properties)
Regulatory approvals	Undertake relevant field assessments (cultural heritage, flora and fauna, heritage) to inform the regulatory approvals process on the uncertainty in the project construction footprint has been narrowed.

10. Complementary actions and dependencies

10.1 Interactions with other constraint measures

The delivery of overbank flows in the lower Goulburn would produce land inundation in NSW, both immediately adjacent to the lower Goulburn and further downstream where water leaves the River Murray and flows north towards the Wakool River. This project therefore has linkages with the constraints project for the Yarrawonga to Wakool reach of the River Murray.

In addition, higher flows along the River Murray inundate some of the same areas in the lower Goulburn and adjacent NSW as are inundated by higher Goulburn River flows. Hence, higher flows along the River Murray at the same time as high flows from the Goulburn River would increase inundation near the river junction above levels estimated in this business case. There is therefore an interaction between the Goulburn and River Murray constraints business cases.

It is also noted that the removal of constraints to the delivery of environmental flows in the Goulburn system would support the creation of larger environmental flow regimes in the River Murray, which would facilitate the delivery of desired watering regimes to important downstream environmental assets, such as Gunbower Forest, through to the Coorong.

Any potential inter-dependencies for this project and its associated SDL resource unit (SS6 Goulburn), in terms of other measures, cannot be formally ascertained at this time. This is because such inter-dependencies would be influenced by other factors that may be operating in connection with this location, including other measures that form part of the final adjustment package, and the total volume of water that is recovered for the environment.

It is expected that all likely linkages and inter-dependencies for this project and its associated SDL resource unit, particularly with the six other key focus areas for physical constraints, would become better understood as the full adjustment package is modelled by the MDBA and a final package is agreed to by Basin governments.

Similarly, a fully comprehensive assessment of the likely risks for this project and its SDL resource unit cannot be completed until the full package of adjustment measures has been modelled by the MDBA, and a final package has been agreed between Basin governments.

10.2 Interactions with the pre-requisite policy measures

In order to maximise the environmental outcomes possible from the use of water recovered for the environment as part of the implementation of the Basin Plan, it was assumed that several important policy initiatives would be implemented. The measures are referred to as the unimplemented policy measures (refer Clause 7.15 (2) of the Basin Plan) or the pre-requisite policy measures.

These measures involve policies to:

a. credit environmental return flows for downstream environmental use, or
b. allow the call of held environmental water from storage during un-regulated flow events.

The successful delivery of the planned flow regimes for the lower Goulburn detailed in this business case would require the implementation of these policies.

In Victoria, the legislative arrangements to support implementation are already in place. These arrangements will be reflected in Victoria's implementation plan for pre-requisite policy measures, due to be submitted to the MDBA in 2016. In accordance with guidelines prepared by the MDBA, the plan will demonstrate that the arrangements to implement pre-requisite policy measures are secure, enduring, fully operable and transparent. For the Goulburn, operational matters, such as an agreed loss rate, would have to be developed and agreed to by GMW and the VEWH/CEWO to implement the return flow policy.

10.3 Interactions with other supply measures

This constraint measure affects the Goulburn (SS6) surface water SDL resource unit. There are no supply measures proposed for this SDL resource unit, and so there would be no direct interactions between this constraints measure and any supply measures within the resource unit.

The removal of constraints to environmental water delivery on the Goulburn would facilitate the delivery of enhanced environmental flows to the River Murray system, so it is likely that there would be interactions between this project and supply measures on the Murray system downstream of its confluence with the Goulburn River.

As noted above in section 10.1, any potential inter-dependencies for this constraints measure and its associated SDL resource unit, in terms of other supply measures, cannot be formally ascertained at this time. This is because such inter-dependencies would be influenced by other factors that may be operating in connection with this location, including other supply/efficiency/constraints measures under the SDL adjustment mechanism, and the total volume of water that is recovered for the environment.

It is expected that MDBA modelling of the adjustment packages would enable the likely linkages and inter-dependencies between this constraints measure and other supply measures to become better understood.

11. Costs and funding arrangements

11.1 Cost estimates

A formal cost benefit analysis has not been completed for this project because it has not been possible to fully identify and properly quantify the complete range of impacts and benefits in the time that was made available to complete this business case. It is anticipated that further work would be needed to complete a thorough analysis, which ensures that the Basin Plan requirement to address third party impacts has been dealt with appropriately. Some consideration of the costs and benefits of this project has been undertaken as part of the business case preparation.

Whilst there are undoubtedly a range of positive environmental benefits from this project, the managed release of small overbank flow events would inevitably create a range of third party impacts, including inundation of some private land. These third party impacts have been assessed in aggregate and the cost estimates include allowances for actions to mitigate these impacts, including payments to acquire voluntary legal agreements to inundate private land. On the basis that the third party impacts have been identified and assessed, the project approach would be to effectively mitigate impacts or fully compensate affected individuals.

The costs to implement this project have been estimated from data and studies available at the time of preparation of this feasibility level business case. Details on the assumptions underpinning selection of project measures and the studies undertaken to inform this business case are provided in Section 9 (Technical feasibility) and Appendix 1 (Studies undertaken).

The costs presented in this document are the estimated costs to deliver the proposed target flow regime at Shepparton (refer to Table 2-1).

It should be noted that the expected upper bound costs for activities have generally been adopted, to ensure as far as possible that this business case provides an estimate of costs which would be sufficient to deliver the proposed project outcomes. In relation to specialist businesses, infrastructure options have generally been preferred where the costs are comparable to easement options, as it is considered that effective infrastructure options are more likely to mitigate impacts and avoid future disputation than easement based solutions for these businesses. Further refinement of studies and preparation of detailed designs etc. as part of the project would further refine and improve the project cost estimates.

All costs quoted in this document are exclusive of GST, and are based on costs estimates developed in 2015 dollar terms. The identified implementation activities have been sequenced over the proposed eight year implementation program starting in 2016/17, and costs have then been indexed using the recommended indexation factor of 2.68% per year to provide costs estimates in nominal dollars across the implementation program. This is consistent with the Commonwealth methodology for cost escalation.

Actions to enable delivery of increased flows

There are a range of actions required to be implemented to enable the release of flows to supplement unregulated tributary inflows originating in the mid Goulburn and lower Goulburn. These actions are identified in Table 11-1, together with their estimated costs.

Table 11-1: Estimated costs – Actions to enable delivery of increased flows

Actions	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated cost ($m)
Development and enhancement of BoM streamflow forecasting coverage in the Goulburn catchment	▪ Preliminary costings, with contingencies included. Final costs to be negotiated with BoM. ▪ Includes allowance for automated interfaces required to transfer BoM forecast data to GMW water management systems	3.52
Expansion of rainfall monitoring and stream gauging network in the mid Goulburn	▪ Estimated allowance for establishment of new combined rainfall and streamflow gauges ▪ Costs based on standard unit rates for these installations ▪ To be installed asap to provide data to improve understanding and forecasting of trib. flows and support development of operating arrangements.	0.55
Development and implementation of e-Water Source modelling tools.	▪ Operational decision making requirements. ▪ Calibration and testing requirements ▪ GMW holds licence rights to key software ▪ Some customisation and interfacing likely to be required.	0.26
Development of revised operational procedures and water accounting protocols, including staff training and capability building	▪ Release planning actions to be documented. ▪ Would also include risk management actions to deal with higher/lower than planned flows. ▪ Water accounting to be automated via operational modelling tools wherever possible ▪ Includes training for GMW, CMA and VEWH/CEWH staff as appropriate. ▪ Training programs to be developed and then delivered over a number of years (funded as a one-off upfront payment). ▪ Capability development includes simulated exercises and shadow operations in real time.	0.27
Review of rates of rise and fall downstream of Lake Eildon	▪ Geomorphic study and modelling ▪ Two year field trial to test any proposed changes, with detailed monitoring and assessment program	0.21
	Subtotal	4.81

Mitigation actions

As noted in section 8, there are a range of expected impacts from providing overbank flows in the lower Goulburn, and mitigation actions have been identified to address the impacts on public and private assets. The mitigation actions have been separately identified for three main reaches –

Eildon to Yea[6], Yea to Goulburn Weir and downstream of Goulburn Weir - as the targeted flows progressively increase moving down the system with implications for the nature and sizing of mitigations actions. The mitigation actions and their estimated costs are set out in Table 11-2 to Table 11-4 below.

Table 11-2: Estimated costs – Mitigation actions Eildon to Yea

Mitigation actions	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated cost ($m) (Flows up to 15,000 ML/day)
Private land mitigation: Easements and private infrastructure works	▪ Inundation impacts on tolerant pastures ▪ Inundation impacts on vulnerable pastures ▪ Inundation impacts on crops ▪ Livestock husbandry ▪ Fencing ▪ Clean up costs ▪ Effects of interrupted access, including loss of grazing, delayed harvesting ▪ Pumps ▪ Cost-benefit analyses of infrastructure vs easements (to determine where upgrades required) ▪ Costs of representative engineering works ▪ Allowance for negotiation and legal costs	5.37
Public infrastructure mitigation: Operational response, reinstatement and capital works on public infrastructure	▪ Asset Managers (Councils) incur additional resourcing costs associated with flood preparations. ▪ Enacting flood mitigation controls (such as road management/closing and shutting off backflow prevention valves) was a common cost, not captured by asset costing. ▪ Rehabilitation of roads (potholes, pavements, regrading) ▪ Maintenance of tracks ▪ Replacement or reinstatement of culverts ▪ Grading and removal of debris in fords ▪ Impacts on landscaped areas ▪ Isolated Property Access road upgrades ▪ Other relevant capital works	0.39
Specialist activities	▪ Infrastructure focussed	10.05
	Subtotal	15.81

[6] Note: MDBA mitigation impacts studies referred to Killingworth, but for consistency with hydraulic modelling and other studies, Yea has been adopted to describe the end of the first major river reach throughout this Business Case.

Table 11-3: Estimated costs – Mitigation actions Yea to Goulburn Weir

Mitigation actions	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated cost ($m) (Flows up to 35,000 ML/day)
Private land mitigation: Easements and private infrastructure works	▪ Inundation impacts on tolerant pastures ▪ Inundation impacts on vulnerable pastures ▪ Inundation impacts on crops ▪ Livestock husbandry ▪ Fencing ▪ Clean up costs ▪ Effects of interrupted access, including loss of grazing, delayed harvesting ▪ Pumps ▪ Cost-benefit analyses of infrastructure vs easements (to determine where upgrades required) ▪ Costs of representative engineering works ▪ Allowance for negotiation and legal costs	9.33
Public infrastructure mitigation: Operational response, reinstatement and capital works on public infrastructure	▪ Asset Managers (Councils) incur additional resourcing costs associated with flood preparations. ▪ Enacting flood mitigation controls (such as road management/closing and shutting off backflow prevention valves) was a common cost, not captured by asset costing. ▪ Rehabilitation of roads (potholes, pavements, regrading) ▪ Maintenance of tracks ▪ Replacement or reinstatement of culverts ▪ Grading and removal of debris in fords ▪ Impacts on landscaped areas ▪ Isolated Property Access road upgrades ▪ Other relevant capital works	4.16
Specialist activities	▪ Infrastructure focussed	16.12
	Subtotal	29.61

Table 11-4: Estimated costs – Mitigation actions downstream of Goulburn Weir

Mitigation actions	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated cost ($m) (Flows up to 40,000 ML/day)
Private land mitigation: Easements and private infrastructure works	▪ Inundation impacts on tolerant pastures ▪ Inundation impacts on vulnerable pastures ▪ Inundation impacts on crops ▪ Livestock husbandry ▪ Fencing ▪ Clean up costs ▪ Effects of interrupted access, including loss of	15.86

Mitigation actions	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated cost ($m) (Flows up to 40,000 ML/day)
	grazing, delayed harvesting ▪ Pumps ▪ Cost-benefit analyses of infrastructure vs easements (to determine where upgrades required) ▪ Costs of representative engineering works ▪ Allowance for negotiation and legal costs	
Levees	▪ Raising levee crest to provide adopted freeboard above adopted "buffer" flow rates ▪ Remediating identified points of weakness	13.06 11.01
Land or easement acquisition for levees	▪ Rights required to ensure future access to levees on private land for inspection, operations and maintenance activities.	0.78
Outlet structures in levees	▪ Current conditions and design of structures ▪ Four structures to be upgraded ▪ Includes costs for remote operation to assist in operational management during events.	7.69
Public infrastructure mitigation: Operational response, reinstatement and capital works on public infrastructure	▪ Asset Managers (Councils) incur additional resourcing costs associated with flood preparations. ▪ Enacting flood mitigation controls (such as road management/closing and shutting off backflow prevention valves) was a common cost, not captured by asset costing. ▪ Rehabilitation of roads (potholes, pavements, regrading) ▪ Maintenance of tracks ▪ Replacement or reinstatement of culverts ▪ Grading and removal of debris in fords ▪ Impacts on landscaped areas ▪ Isolated Property Access road upgrades ▪ Other relevant capital works	16.47
Specialist activities	Easement focussed[7]	2.57
	Subtotal	67.44

[7] Easement focussed option adopted for lower Goulburn, as infrastructure option was significantly more costly – details to be further developed during implementation phase.

In addition to these reach specific mitigation actions, there are some mitigations that would be relevant to all reaches of the mid and lower Goulburn. These actions are detailed in Table 11-5.

Table 11-5: Estimated costs - Other mitigation actions

Mitigation actions	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated cost ($m)
Refine hydrologic modelling	▪ Address limitation identified as part of feasibility level study. Includes testing use of actual forecast data to trigger simulated release for Lake Eildon, extending modelling to sub-daily timestep and development of explicit loss relationships for overbank flow events	0.37
Groundwater monitoring	▪ Install up to 6 shallow piezometers to monitor shallow water table response to overbank flows ▪ Review (and modify) preliminary assessment of salinity impacts of measure.	0.08
River avulsion risk study	▪ Review and assess risks of river avulsions, particularly in the lower Goulburn.	0.05
Inundation modelling	▪ Developing new, and/or and refining existing hydraulic models of inundation ▪ On-ground assessment of actual flow events, involving local stakeholders (e.g. monitoring and measuring flows over specific properties) ▪ Aerial photography of actual flow events	1.55
	Subtotal	2.05

Annual operation and maintenance costs

Wherever possible, future annual costs have been assessed and their present value estimated to facilitate one-off upfront payments, especially to individuals or organisations that may have costs to address third party impacts. This approach is likely to significantly reduce future transaction costs that would otherwise be required to address the response to flow events etc. There would, however, be some annual costs for the operation and maintenance of key infrastructure. The estimated annual costs for these activities are provided in Table 11-6.

Table 11-6: Estimated annual operation and maintenance costs

Mitigation actions	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated O&M cost ($m/yr)
Levees	▪ Annual condition inspection ▪ Planned maintenance. ▪ Annualised cost of breach repairs for active sections of levee following major natural events. ▪ Pre event inspection of levees to determine if event conditions can be safely undertaken.	0.61
Outlet structures	▪ Gate maintenance	0.10

Mitigation actions	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated O&M cost ($m/yr)
	▪ Communications tower maintenance	
Rainfall and stream gauging network	▪ Only includes costs for additional sites to be added for project	0.04
BoM streamflow forecasting services	▪ Preliminary costings, with contingencies included. Final costs to be negotiated with BoM.	0.35
	Subtotal	1.10

Program management costs

It is not yet known what governance and implementation arrangements might be finally agreed, if this measure were to be implemented (refer also to section 14 for implementation projects)

It is considered that the equivalent of one "program management group" would be required to implement this measure. If it is assumed that such a program management group would have to be resourced from scratch (i.e. existing resources cannot be mobilised) the indicative cost for program management is approximately $1 million per annum, or $8.4 million over the period 2016 to 2024.

In addition to the direct program management costs, there will be a significant need for community and landholder engagement activities across the whole project implementation period. This will cover the necessary communications and engagement specialist resources needed to manage relationships with all key stakeholder groups throughout activities including negotiations for easements and works, and the conducting of trial releases to test and monitor the augmentation of tributary inflows. The estimated total cost for communications and engagement is $12 million over the eight year implementation period.

Initial implementation costs

If this project proceeds to the implementation phase, given that this is a feasibility level business case, there are a range of further studies needed to further develop and test operating principles and develop a more refined assessment of third party impacts, mitigation options and costs (refer section 9.5). These activities are planned to occur over the first three years of the eight year implementation period.

Costs for these activities are detailed in Table 11-7. It should be noted that these costs represent the first 3 years of the implementation program. These costs are all incorporated in the total costs for each of the project elements set out in the earlier parts of Section 11.

Table 11-7: Years 1-3 implementation activity costs

Activity	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated cost ($m)
Refine hydrologic modelling	▪ Address limitation identified as part of feasibility level study. Includes testing use of actual forecast data to trigger simulated release for Lake Eildon, extending modelling to sub-daily timestep and development of explicit loss relationships for overbank flow events	0.37

Activity	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated cost ($m)
Expansion of rainfall monitoring and stream gauging network in the mid Goulburn	▪ To be installed asap to provide data to improve understanding and forecasting of trib. flows and support development of operating arrangements.	0.31
Review of rates of rise and fall downstream of Lake Eildon	▪ Geomorphic study and modelling ▪ Two year field trial to test any proposed changes, with detailed monitoring and assessment program	0.21
Groundwater monitoring	▪ Install up to 6 shallow piezometers to monitor shallow water table response to overbank flows ▪ Review (and modify) preliminary assessment of salinity impacts of measure.	0.08
River avulsion risk study	▪ Review and assess risks of river avulsions in the lower Goulburn.	0.05
Preliminary and detailed design of levee upgrades including statutory approvals and assessment of land acquisition.	▪ Preparation of detailed designs and costings, including geotechnical investigations and identification of suitable sources of borrow etc. ▪ Develop detailed submissions required to obtain necessary statutory approvals	3.27
Preliminary and detailed design of levee outlet structures including statutory approvals	▪ Preparation of detailed designs and costings, including geotechnical investigations. ▪ Develop detailed submissions required to obtain necessary statutory approvals	1.38
Inundation modelling	▪ Developing new, and/or and refining existing hydraulic models of inundation ▪ On-ground assessment of actual flow events, involving local stakeholders (e.g. monitoring and measuring flows over specific properties) ▪ Aerial photography of actual flow events	1.01
Development and implementation of e-Water Source modelling tools.	▪ Operational decision making requirements. ▪ Calibration and testing requirements ▪ GMW holds licence rights to key software	0.26
Development of revised operational procedures and water accounting protocols, including staff training and capability building	▪ Release planning actions to be documented. ▪ Would also include risk management actions to deal with higher/lower than planned flows. ▪ Water accounting to be automated via operational modelling tools wherever possible ▪ Training programs to be developed and then delivered over a number of years (funded as a one-off upfront payment). ▪ Capability development includes simulated exercises and shadow operations in real time.	0.09
Specialist business measures	▪ Detailed investigation and design of suitable packages of measures for each specialist business.	1.19

Activity	Issues taken into account in estimating costs (further details in Appendix 1)	Estimated cost ($m)
Private land mitigation	▪ Ground truthing of impacts, mitigation measures and easement costs, at a property-by-property level ▪ Property-by-property assessment required to identify specific private works that are affected, and specific mitigation measures required	1.60
Public infrastructure mitigation	▪ Ground-truthing of impacts, mitigation measures and costs.	0.87
Program management	▪ Manage project activities including complex investigations and design works ▪ Includes cost to develop a revised and updated business case.	3.37
Community and landowner engagement	▪ Manage relationships with all key stakeholder groups throughout detailed investigation, design and impact assessments.	4.21
	Subtotal	18.27

Summary of estimated cost

The overall estimated costs to further develop and implement the project detailed in this business case are summarised in Table 11-8. The total upper bound cost, based on feasibility level assessments and costings is $140.12 million.

Table 11-8: Summary of estimated costs

Item	Estimated cost
Capital expenditure	**($m)**
Actions to enable delivery of increased flows	4.81
Mitigation actions: ▪ Eildon to Yea reach ▪ Yea to Goulburn Weir reach ▪ Downstream of Goulburn weir reach ▪ Other mitigation actions	 15.81 29.61 67.44 2.05
Program management	8.4
Community and landholder engagement	12.0
Total estimated cost	$140.12[8] m

[8] All capital costs to implement the proposal have been scheduled across the 8 year implementation period. Indexation has been applied to these costs, which are shown in nominal dollars.

O&M expenditure	($m/yr)
Annual O&M	1.1
Total estimated annual cost	$1.1 m/yr[9]

11.2 Assumptions and uncertainties

Table 11-9 summarises key assumptions and caveats associated with the key elements of the cost estimates, and the implications of those assumptions and caveats for the level of certainty associated with the estimates. Further details on the methods used, approach taken and data sources are provided in Appendix 1.

Table 11-9: Assumptions and caveats associated with the cost estimates

Issue	Assumption/caveat	Implications for cost estimates
Hydrology	For costing purposes, it has been assumed that the outcomes of that hydrological modelling represent an outer envelope of what is hydrologically feasible, if constraints were relaxed.	Expected to result in overestimate rather than underestimate
Easements	Assume that land values, agricultural gross margins and impacts of higher flows can be generalised in a model. Model assumptions have been "ground truthed" through consultation with relevant local experts, but by necessity they are still average values. In reality they would vary from property from property.	Estimates are considered fit for purpose at regional level but not at a more local scale. A contingency of 10% has been built into the easement costs Cost estimates include indexation for inflation, however no allowance included for possible real increases in land values over the duration of the implementation phase.
Easements – administrative costs	A $5,000 "administration" cost has been assumed per property. These costs include establishing the criteria for calculation of the level of compensation, site inspections and negotiations with land owners and legal costs to include easements on land titles. Based on previous experience in negotiating easements along the Hume-Yarrawonga and Mitta-Mitta regions.	Estimate may be too low if stakeholders require a different level of administrative cost to what was required in Hume-Yarrawonga.
Private crossings	In the context of the timeframes available for the feasibility work, and associated constraints to on-ground consultation with landowners, it was not possible to identify precisely which private crossings would require	Estimates are considered fit for purpose at regional level but not at a more local scale. A contingency ranging from 50 to 160 percent has been built in.

[9] Annual O&M expenditure is shown in 2015 dollars

Issue	Assumption/caveat	Implications for cost estimates
	infrastructure works. The number of private crossings, and the nature of works required, has been estimated on a regional basis, drawing on intelligence gathered from sample "case study" properties.	Estimates are considered more likely to be overestimates than underestimates.
Capital works on public infrastructure	These assets were identified by stakeholders (e.g. councils) and reviewed by engineering experts (AECOM). However, there were practical limitations to the level of detail to which cost estimates could be made for these works.	Cost estimates are considered "prefeasibility" in terms of accuracy. A contingency of 15 to 60 percent has been built in in to the base cost estimates. A further 12 to 160 percent contingency has been added to cover potential additional implementation costs. Estimates are considered more likely to be overestimates than underestimates.
Reinstatement works on public infrastructure	Identified through a desktop analysis, supplemented by consultation with stakeholders (e.g. councils). However, there were practical limitations to the level of detail to which the consultation process could consider individual infrastructure items.	Estimates are considered fit for purpose at LGA level but not at a more local scale
Works on levees	Identified based on detailed survey and analysis of raising required and engineering unit rates for earthworks	Estimates are feasibility level Contingencies of 50% on levee raising and 100% on remediation of points of weakness to reflect limited knowledge of structural conditions. Costs are considered adequate based on expert review.
Outlet regulators	Concept design prepared and unit rates for recent similar works used for costing	Contingencies of 40% included to cover uncertainty Estimates considered to reasonable for feasibility level purposes and current scope.
Specialist activities	Identified through a desktop analysis, supplemented by selected "case studies" from which costs have been extrapolated.	Estimates are considered fit for purpose at regional level but not at a more local scale, or for individual activities (or categories of activity). A contingency of 100 percent has been built in to base cost estimates. A further 5 to 100 percent contingency has been added to cover potential additional implementation costs. Estimates are considered more likely to be overestimates than underestimates.

11.3 Proposed funding arrangements

Should this project go ahead, Victoria would be seeking 100 per cent of project funding from the Commonwealth. The funding requested would be used to: finalise necessary stakeholder consultation to confirm the project is fully supported by affected communities; is construction ready; is built in accordance with all regulatory approval requirements and conditions; and is fully commissioned once construction is complete.

11.4 Proposed funding source

Should this project proceed, Victoria will be seeking 100% of project funding for this constraint measure proposal from the Commonwealth. The funding requested will ensure that the proposed constraint measure is construction ready, built in accordance with all regulatory approval requirements and conditions, and fully commissioned once construction is complete.

11.5 Ongoing ownership and maintenance

The delegation of asset ownership and operation in relation to this project, including any associated financial responsibility, cannot be confirmed at this time. Victoria currently has agreed arrangements in place through the BSOG to resolve asset ownership arrangements for its nine works-based supply measures. This process would inform any arrangements that are finalised for this project. A formal position on this matter will be clarified as part of the broader decision process as to whether or not this project will proceed.

12. Consultation and engagement

12.1 Communications and engagement plan

A Communications and Engagement Plan (GBCMA, 2015) was developed to guide communications and engagement throughout the Phase 2 investigations (through to June 2016) for the Goulburn Constraints Measure.

The plan was developed in line with the best practice standards set out by the International Association for Public Participation (IAPP 2006) to achieve one of the key principles underpinning the Constraints Management Strategy: *Affected communities, including landholders and managers, water entitlement holders, Traditional Owners, management agencies and local government need to be involved from the beginning to identify potential impacts and solutions* (GBCMA, 2015).

Engagement activities have been led by the MDBA and GBCMA and have sought to:

- share the purpose of the Constraints Management Strategy and its associated implications
- gain local knowledge and feedback on the movement of overland flows across the landscape
- better understand the potential effects of such flows (positive and negative) at a regional level
- assist in the development of mitigation options that may address negative effects on stakeholders.

It is important to note, that the Goulburn Constraints Measure affects an estimated 562 properties. Opportunities for *individual* consultation with directly affected landholders have been limited during the Phase 2 feasibility investigations due to time constraints. This will be a critical component of the ongoing stages of the project should it proceed (section 12.5).

12.2 Key stakeholders

Stakeholders for the Goulburn Constraints Measure have been categorised to ensure an appropriate level of consultation and engagement according to:

- direct decision making or approval role in the project (group 1)
- directly impacted (positively or negatively) by the changes (group 2)
- likely to be significantly interested in the project activities (group 3).

A summary of the key stakeholder groups is provided in Table 0-1 over page. Further information on the specific stakeholders and their interest in the project can be found in the Communications and Engagement Plan (GBCMA, 2015).

Table 0-1: Stakeholders for the Goulburn Constraints Measure

	Category	Stakeholder Group
Internal	Group 1: Agency stakeholders	Goulburn-Murray Water Murray-Darling Basin Authority Goulburn Broken CMA DELWP Parks Victoria Victorian Environmental Water Holder, Commonwealth Environmental Water Office Department of Economic Development, Jobs, Transport and Resources Other statutory approval authorities e.g. local government, Registered Aboriginal Parties
External	Group 2: Potentially impacted stakeholders	Landholders, frontage licence holders and landholder representatives Water users along the river Specialist primary industries Leisure and tourism industry Local Government Traditional owners and other indigenous people Public land users (recreation and lifestyle) Water Authorities
	Group 3: Interested stakeholder	Environment groups Townships Emergency managers, warning and rescue services Melbourne/state residents State and Federal Members of Parliament Agricultural organisations e.g. Victorian Farmers Federation

12.3 Overview of communications activities in developing the business case

As stated above, the very short timelines for the development of this business case limited the amount of consultation possible. The three community advisory groups convened by MDBA in 2013 met several times during 2015 and 2016. Key agency stakeholders were directly involved via the project steering committee in project development. Other agencies were consulted as required.

Community consultation focused on directly affected landowners. Letters were sent to approximately 1,300 affected landowners on three occasions. The first two letters advised them of the project and invited them to attend one of eight open house meetings in August 2015 and nine in January 2016. The third letter in December 2015 advised landholders of the change in the project submission date. Approximately 200 people attended the August open house meetings and 246 attended the open house meetings in January. MDBA staff and contractors also visited individual properties to carry out assessments to inform the technical investigations underpinning the business case.

Knowledge was documented in two case studies, as well as the update of the MDBA's Goulburn River Reach Report (MDBA, 2015b). Four specialist businesses were inspected and a fifth contacted to understand issues associated with those businesses. Local government staff were consulted to understand the impact of flooding on local government assets, particularly roads, bridges and walking/bike paths.

Briefings were also provided to indigenous group representatives, most local government councils, and most local politicians.

12.4 Traditional Owner views

The Yorta Yorta Nation Aboriginal Corporation is generally supportive of any investment and activities which would aim to bring a more natural flow regime to the Goulburn River and floodplain on their country. They see such opportunities as supporting cultural values for traditional owners not only along the Goulburn River but along the River Murray downstream. Such measures would align with their Whole of Country Plan. If the business case were to be supported, Yorta Yorta would be interested in opportunities to increase their capacity around the management of river, floodplain and wetland systems and associated flows.

The Taungurung Clan Aboriginal Corporation see the increased frequency and extent of small overbank flows along the Goulburn River and floodplain as providing huge cultural benefits. They believe that there would be a strong overlap in environmental and cultural values of such an initiate and that it would align with the intent of their draft Country Plan. Taungurung see the additional rainfall and flow gauging proposed under the business case of value to them and necessary even if the project was not funded. Taungurung would also like to take any opportunities that would arise from the implementation of the business case that would enable further involvement of Taungurung people in river and floodplain management.

12.5 Community views

Landowners are worried about the proposal to deliver environmental flows at higher levels and the subsequent effects on them and their businesses. Key concerns include unpredictability of rainfall (imperfect forecasting), and the inadequacy of the existing river and rainfall gauging network. Some concerns were expressed about the accuracy of inundation mapping and the uncertain future of the lower Goulburn levee system. These concerns are recognised as project risks (section 8).

People were generally very unhappy that a decision regarding further implementation through the Basin Plan process will be made before property level assessments are carried out. People feel that everyone who could be directly affected should know this and be able to input before a decision is made. As discussed in section 1.2 it is anticipated that a further decision point will be formally incorporated into Phase 3 following the completion of further investigations and consultation.

A flow of 20,000 ML/d between Eildon and Molesworth was confirmed as 'untenable' as a community view from those who attended mid Goulburn meetings during August 2015. A flow of 40,000 ML/d at Shepparton was also confirmed as being of significant concern in the lower Goulburn at this time, but more on the basis of risk rather than direct impact (i.e. if the target flow was 40,000 ML/day, actual flows could be higher for a range of reasons).

For a number of farmers between Eildon and Yea (>15 people), there is concern that farm viability is at stake as they currently rely on river flat productivity to support grazing on surrounding poorer quality hill country (or they may not have access to hill country to agist or move stock and totally rely on the river flats).

People that spoke up at the mid Goulburn sessions want Governments to know they do not want easements. Many want to keep farming their land as they currently do and view easements and the associated impact on property values as an erosion of their property rights. These views are recognised as project delivery risks (section 14.2).

For the lower Goulburn, work on delivery constraints raises the possibility of investment in the protective rural levee network downstream of Shepparton. This is appealing as many people rely on the levees. However significant concern remains as capital investment doesn't address long-standing levee ownership and ongoing maintenance issues. This issue was captured though the risk assessment process (Appendix 7).

Further, a key issue throughout the whole Goulburn River is flood risk. Not enough detail is currently available to answer questions regarding how environmental water could be used to top-up tributary flows and what the risk is of getting the event wrong (flows higher than anticipated or targeted) or making flooding during a follow-up event worse (i.e. need event case studies or proof of concept). The further investigations proposed through this business case seek to address this concern.

Key feedback gained through consultation with community advisory groups and landholder meetings that helped shape this business case included:

- *The timing of flows is important:* The impacts increase if flows occur during late spring, as it coincides with pasture growth periods and affects subsequent feed reserves (hay production) or capacity to re-sow pasture.
- *The duration of flows is important:* Loss of pasture would occur if inundation persists beyond the expected duration and can reduce feed reserves as stock cannot be returned to the floodplain until it dries out.
- *The magnitude of flows is important:* as discussed previously.
- *Notification of impending releases:* Early notification of managed releases is needed to assist with farm planning, as well as improved flood warning notification systems and rainfall measurements.

After the open house sessions in January 2016, the proposed target flows and risk management buffers, while still a significant concern to some sections of the community, particularly in Molesworth, were more widely accepted. This statement is supported by the results of the feedback sheets filled in by attendees.

The following outlines the key points raised at January open house sessions

Target flow rates

- Although the community is relieved the 40,000 ML/day target flow rate in the lower Goulburn and the 20,000 ML/day flow target in the mid-Goulburn are no longer being considered in the business case, there was still significant concern about revised lower flow targets.
- Molesworth landholders were concerned not only over the buffer level (and whether it is adequate), but also at the target flow rate of 10,000 ML/day at Alexandra. This is partially due to uncertainty as to what a 10,000 ML/day flow at Alexandra could turn into by the time it moves downstream to Molesworth, but also with concern regarding Alexandra.
- The duration of flow events have not been defined tightly enough, especially as it is a major driver of the amount of damage that is done.
- There was concern too that decision makers could increase target flow rates in the future and decrease the protection sought through the buffer levels.

Flow footprint mapping

- The community is concerned the flow footprint mapping in the Molesworth and Alexandra regions is not accurate and therefore the number of properties and public land, and the size of area affected by the target flow rates and the buffer levels are considered underestimated.

Mitigation and offset costs

- There is a lot of confusion about attempting to calculate an upfront cost large enough to pay for a recurrent flood event in perpetuity. Some landholders suggested an event based compensation process would be preferred.
- The community questioned the costing assumptions used to determine land worth – both that an 'agricultural value' was being used, and the level of compensation, and that clean-up costs after a flow event were inaccurate or inappropriate.
- There was considerable concern about compensation for the decreased production value of the land, pointing out it didn't take into account the potential decrease in market value for the whole property, nor the effect on other 'lifestyle' components of market value, i.e. aesthetic characteristics and access beyond agricultural purposes.
- The community said there would need to be independent legal and farm advice provided for affected landholders, not just advice at a community reference group level as currently costed in the business case.
- Is the future potential of the land taken into account, not just its current use?
- How is the contribution of the affected land to the whole farm enterprise costed? The impacted land could be integral to the functioning and feasibility of a farm (primary source of water, stock feed, shelter).

That the following costs have not been detailed in the business case:

- Impacts on Goulburn River landholders from flow interactions with the Murray River.
- Impacts on tributary landholders (e.g. Broken River and Seven Creeks) from flow interactions with the Goulburn River (also see comment under "Other" heading below).
- Councils who want some of their public infrastructure assets to be upgraded to maintain access rather than the current costing assumption of reinstatement.
- If property values decrease it could decrease the rate income to councils.
- Flow on effects to the economy and community (other businesses in the region) from reduced tourism because of increased flooding.
- Contribution to Loch Garry operation and maintenance as constraints flows are relying on the structure to be in place and remain in good condition.
- River bank erosion and avulsion control as a consequence of increased flooding.

Easements

- How would easement acquisitions be negotiated?
- Local community reference groups should provide input into the design and implementation of the easement acquisition process, if it occurred.
- Vulnerable landholders (e.g. the elderly and people with mental health issues) should be considered in the design and implementation of the easement acquisition process.
- There was concern easement acquisitions would not stay voluntary and would become compulsory.
- Affected landholders should be provided with access to independent farm and legal advice at an individual property level.

Other

- Exacerbated flood risk (risk of making a follow up flood worse) continues as a key community issue all along the Goulburn River. This relates to uncertainty around how tightly flows can be managed during an event, whether the buffers are of sufficient size, whether the mapping is accurate at a local level, and for the lower Goulburn how much the filling up of the floodplain storage (wetlands) could affect the severity of a follow up flood.

- People in the mid-Goulburn were unhappy that tributary impacts were only recognised as needing further work and were not included in any cost estimates in the business case; work this year showed limited impact on backing up and tributary time to drain which doesn't match with landholder views.
- Participants in the sessions were unhappy that governments are making decisions without all the information being in place.
- The assumption of predominantly public infrastructure reinstatement rather than upgrade is considered risky by some councilors. View was put that where properties and business could be isolated for seven days or more, infrastructure should be upgraded.
- There was some thought that a real time river level monitoring phone app with advance notification capability would assist affected landholders and communities, however there was concern on any reliance of BoM to provide accurate weather predictions prior to flood events.

A summary of the feedback received at the January 2016 open house sessions is provided in Appendix 8.

12.6 Council views

Consultation with councils has been undertaken during the development of the business case and is ongoing. Council concerns include thee potential economic, environmental, and social impacts arising from increased environmental flows.

12.7 Arrangements for ongoing consultation

This project involves significant change for hundreds of land and business owners located over 440 km of the Goulburn River. As such, each owner would face significant uncertainty and adjustment which would need to be worked through over time. This includes understanding their particular issues and developing and negotiating appropriate mitigation options for each circumstance. In addition, there are many people indirectly affected or interested that need to be engaged and informed.

The different phases of the project would require different approaches to communication and engagement. Accordingly, a new communication and engagement strategy would be needed for the implementation phase. In particular, the strategy would need to take into account the concerns raised by the community which have been identified as potential barriers to the successful implementation of the project (section 14.2).

In summary, the project would impact 562 properties and other concerned parties, local businesses, traditional owners, six councils and a range of government agencies including GMW, Park Victoria. Hence, the communications and engagement requirement for the project is substantial and will need to be delivered over a long period of time (eight to 12 years).

The strategy would need to provide a framework to inform and support people throughout the project development, implementation and initial operation phases of the project. During the development phase, information on individual properties/businesses needs to be gathered, along with impacts of increased inundation, and potential mitigation options.

Involvement of owners in inundation measurement trials or natural events would be important in gaining confidence in the extent of inundation. During the implementation phase, mitigation measures need to be discussed and negotiated, and then put in place. In initial operation of the measure, the monitoring of releases and their impacts would be important to gain confidence that the inundation is as planned and the mitigation has been effective.

The strategy also needs to deal with infrastructure on public land, particularly roads and levees. This would involve dealing with government agencies, particularly local government and Parks Victoria, but would also involve providing information to the public interested in those assets.

The estimated cost of implementing this strategy is $12.0 million as shown in section 11.1 and includes provision for ongoing consultation across the first three years of operation (to June 2027). The cost estimates allow for staff time to deliver the communications activities, as well as costs of project related material and activity.

13. Legislative and policy requirements

DELWP has developed a Regulatory Approvals Strategy for the Goulburn Constraints Measure (DELWP, 2015) which maps out a broad approvals pathway for the under State and Commonwealth legislation. Approvals refers to all environmental and planning consents, endorsements and agreements required from Government agencies by legislative or other statutory obligations to conduct works. The strategy identifies the relevant legislation governing the proposed actions, the type of approvals likely to be required and an indicative program for obtaining the necessary regulatory approvals (DELWP, 2015).

A summary of the potential approvals required for this project is presented in Table 0-1.

In addition to applications, a range of supporting documentation would be required or are likely to be requested through referral decisions or planning permit conditions (DELWP, 2015). The costs of preparing these documents are included in the overall costings for this project (Section 11).

It is not possible to capture all permit requirements at this stage as the project is not developed sufficiently. The Regulatory Approvals Strategy therefore represents the approvals likely to be required at time of writing. The strategy would need to be reviewed once the project scope and associated works are confirmed, prior to commencing the approvals.

The Victorian government has recently released a Revised Draft Victorian Floodplain Management Strategy, which outlines proposed government policy positions on a range of floodplain management issues including flood mitigation works such as levees. The Revised Draft Strategy has been the subject of extensive community consultation, and the government is expected to release a final strategy in 2016.

The Revised Draft Strategy is primarily concerned with managing and mitigating natural flooding events, whereas this project aims to manage the third party impacts of managed environmental water releases. As a result, whilst the new and upgraded levees proposed would not be recognised as formal flood mitigation infrastructure, and therefore local government would not take these levees into account in its land use planning processes (e.g. issue of permits for residential house construction etc.), they may still offer valuable flood mitigation benefits to land holders.

The Revised Draft Strategy does not encourage the widespread construction of new levees for rural flood protection, but does acknowledge that there are circumstances in which new rural levees would be considered. The primary example cited is where new levees are required to enable environmental watering (i.e. projects such as this one). The Revised Draft Strategy includes policy provisions to cater for the maintenance of rural levees that are not formally recognised as flood mitigation infrastructure. Changes to the *Water Act 1989* enacted in 2014 established a permit scheme for the maintenance of levees located on Crown land, including in national parks.

This business case is expected to be compatible with the policy directions being finalised for rural levee systems in Victoria.

No other amendments to state legislation or policy are anticipated. This includes no formal amendments to state water sharing frameworks. Further to this, no changes to the Murray-Darling Basin Agreement 2008 are required to implement this measure, nor do any new agreements need to be created either with other jurisdictions or water holders in the Basin.

State policy on water tariffs, associated with use of the irrigation system, is currently being reviewed. This may influence the costs associated with delivery of environmental water but not the feasibility of delivery.

Table 0-1: Regulatory approvals anticipated for the Goulburn Constraints Measure

Approvals required	Description
Commonwealth legislation	
Environmental Protection & Biodiversity Conservation Act 1999: Referral	The project may affect a number of potentially affected "matters of national environmental significance" (MNES): ▪ Ramsar sites (either directly affected, in the vicinity or downstream) ▪ Migratory waterbird species (JAMBA, CAMBA, ROKAMBA) ▪ Nationally threatened species and communities
Native Title Act 1993	Applicant to notify native title claimants of any future act that permits or requires the construction, operation, use, levee or other device for management of water flows.
Victorian legislation	
Environmental Effects Act 1978: Referral	Likely to meet at least one of the six referral criteria for individual potential effects i.e. 1. Potential clearing of 10 ha or more of native vegetation from an area that is: • an Ecological Vegetation Class identified as endangered or (is likely to be) of very high conservation significance (as defined in accordance with Appendix 2 and 3 of Victoria's Native Vegetation Management Framework), and • not authorised under an approved Forest Management Plan or Fire Protection Plan.
Planning & Environment Act 1987: Planning permit and Public Land Managers Consent	Applicant to request permission from public land manager to apply for a planning permit for works on public land. A planning permit application is then submitted with supporting documentation which is likely to include an Offset Strategy and a Threatened Species Management Plan. Local Council refers applications and plans to appropriate authorities for advice.
Aboriginal Heritage Act 2006: Cultural Heritage Management Plan	A CHMP is required when a listed high impact activity would cause significant ground disturbance and is in an area of cultural heritage sensitivity as defined by the Aboriginal Heritage Regulations 2007 (Part 2, Division 5). To be prepared by an approved Cultural Heritage Advisor.
Water Act 1989: Works on waterways permit	Application for a licence to construct and operate works on a waterway.
Traditional Owner Settlement Act 2010	Likely to require negotiation or consultation with the Yorta Yorta Joint Body regarding activities on Crown land subject to the Yorta Yorta Co-operative Management Agreement. The Victorian Government is currently negotiating a settlement agreement with the Taungurang Clans; negotiation or consultation with this group is also likely to be required.
National Parks Act 1975: Section 27 consent	Approval for a public authority to carry out its functions in a national park.
Flora & Fauna Guarantee Act 1988: Protected flora licence or permit	Application for approval to remove protected flora within public land for non-commercial purposes. Targeted surveys would be needed for threatened/protected species considered likely to be present at the site and impacted by proposed works.

14. Project governance and management arrangements

14.1 Proposed governance and project management arrangements

Should this project proceed, appropriate governance and project management arrangements will be put in place by Victoria to minimise risks to investors (the commonwealth Department of Environment) and other parties, as described below in Figure 22.

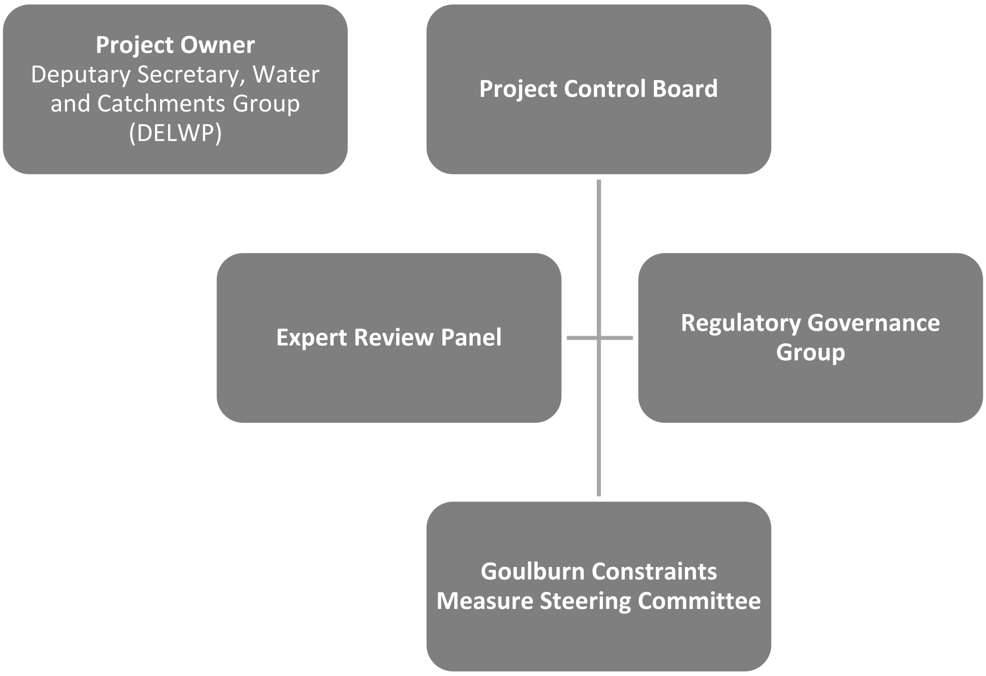

Figure 22: Governance arrangements during business case development

Project Control Board

DELWP convened a Project Control Board (PCB) to oversee the development of business cases for Victoria's supply and constraints measures. The PCB is comprised of senior executives from DELWP, relevant CMAs, G-MW and Parks Victoria to ensure high level engagement of responsible agencies. The PCB's role has been to oversee the development of Victoria's business cases, and to identify and resolve program-level issues.

The PCB is supported by an Expert Review Panel, Regulatory Governance Group and the Goulburn Constraints Measure Steering Committee.

Expert Review Panel

The Expert Review Panel ('the Panel') was originally established to support the development of supply measure business cases. The Panel has examined the critical elements of the business case at key stages to assess quality, credibility and whether the measures are fit for purpose. The Panel is comprised of experts in engineering (including geotechnical, structural, hydraulic and water system operations) and hydrology. Its members include:

- Phillip Cummins (engineering)
- Shane McGrath (engineering), and
- Dr Chris Gippel (hydrology).

As discussed in sections 9 and 11, peer reviews have been prepared to assist the business case completion and include:

- Engineering: Review of concept engineering designs to support water management structure design (SGM Consulting Pty Ptd, 2016) and construction costs for the lower Goulburn levees (SGM Consulting Pty Ltd, 2015; SGM Consulting Pty Ltd, 2015), and
- Hydrology: Review of hydrodynamic and hydrological models, data, modelled scenarios and outputs (Fluvial Systems, 2016).

The individual reviewers have concluded the engineering and hydrology investigations as fit for purpose.

Regulatory Governance Group

The Regulatory Governance Group (RGG) was established to provide advice to the PCB regarding the regulatory approvals needed for Victorian supply and constraints measures. The RGG is comprised of relevant staff from Victorian approvals agencies, including DELWP, Parks Victoria and the Office of Aboriginal Affairs Victoria. The RGG has provided a mechanism for high-level engagement with responsible agencies at an early stage to identify the approvals likely to be required, opportunities for efficiencies and areas of potential risk.

Project Steering Committee

At a project level, the Goulburn Broken CMA has convened a Project Steering Committee that comprises representatives from GMW, GBCMA, Parks Victoria, DELWP and MDBA

The role of this committee has been to:

- provide technical advice on the development and proposed delivery of the project
- ensure the project findings are technically rigorous and sound
- monitor statutory and policy issues, including the identification of issues that may impede the success of the project
- assist with the interpretation of policy and legislation relevant to their agency
- advise on processes to resolve issues relative to their agency
- identify issues associated with the proposed works that may impact upon project implementation, including any policy changes
- disseminate information within their respective agencies regarding project progress and issues.

14.2 Risk assessment for project development and delivery

The *Goulburn Constraints Management Project: Risk Management Strategy* (Tranter, 2015) takes into account risks associated with the project development and delivery stages.

Previous sections of this business case have focussed on the project's potential adverse impacts to the environment or third parties. The assessment of project development and delivery risks focuses on those risks that pose potential project delays and could result in cost increases, loss of goodwill, legal action or, in the worst case scenario, threaten project feasibility.

Risks identified through this process were evaluated using the approach outlined in Appendix 6. The full suite of risks considered by the assessment process is documented in Tranter (2015) and a summary of pre-treatment risks with a rating of significant or higher is provided in Appendix 7.

Residual risks

Understanding and controlling these risks is a routine part of project management therefore a standard set of controls exist that have been applied to this project. Most risks identified through the evaluation process can be managed by these current controls, as shown in Appendix 7.

The remaining priority risks that need to be managed by the project are summarised in Table 0-1. These risks are considered to be a high priority for management in the ongoing stages of the project.

14.3 Project plan for implementation

Project delivery arrangements

Once a decision has been made to proceed, to ensure this project is delivered on time, arrangements would be put in place that ensure appropriate senior oversight of project governance and delivery. It is envisaged that these arrangements would be informed by those that were used to deliver the four *Living Murray Environmental Works and Measures Program* (EWMP) projects within Victoria, complemented with existing state government frameworks, which together would underpin a set of robust and thorough processes for procurement and project management.

A detailed scoping of the governance and project management arrangements would be carried out if it is agreed that this project will be included in the final adjustment package. Relevant sections of the Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases would be drawn upon in finalising the governance and project management arrangements for this project, to ensure that all relevant matters are identified and addressed.

Timelines

The project largely falls into 3 phases - investigation and detailed design, implementation, and commissioning.

The first phase would occur from 2016/17 to 2018/19. This involves further investigation of how and when to add releases to unregulated tributary flows, the inundation associated target and buffer flows, the detailed design of lower Goulburn levee and levee outlet upgrades, the detailed assessment of on-farm and specialist business mitigation, and the detailed assessment of public infrastructure needs. The commencement of building flow management knowledge and tools would occur in this period.

The second phase (implementation) would occur from 2019/20 to 2023/24. This would involve implementing the levee and levee outlet upgrades in the first 3 years, and negotiating on-farm easements/works and public infrastructure needs and putting agreements in place. There is a significant risk that putting agreements in place could take longer than the 5 years allowed. The development of flow management knowledge continues through this period.

The third phase (commissioning) would likely occur in two periods. Levee infrastructure could be tested by a natural flow event in 2022/23 to 2023/24 (but later if dry conditions occur). The commissioning of flow management (ie the actual release of water) is planned to start in 2024/25 (assuming all mitigation measures are in place) and commence at a low flow, progressively targeting higher flows over a few years as experience in releasing and risk management is gained. Hence commissioning of flow management would occur over at least 3 years after 2023/24. This would also involve “commissioning” associated public and private inundation extents and associated mitigations (involving extensive monitoring).

The high level draft implementation plan is shown in Figure 23.

Table 0-1: Summary of priority project management and delivery risks once control activities are implemented

Risk	Control Activity	Justification
Lack of support – directly affected stakeholders	Communication plan to include landholder consultation and briefings to fully inform stakeholders, identify and address any issues.	This is considered a **significant risk** as it is likely to be difficult gaining unanimous support from directly affected landholders and there are limited controls in place. The key control is a communications and engagement strategy that aims to fully inform stakeholders and appropriately address all issues. Due to the implications for project delivery, review of the effectiveness of this strategy would need to be monitored by the PCB through any ongoing stages of the project.
Lack of political support	Communication plan to include political consultation and briefings about the project and appropriately deal with stakeholder issues.	This is considered as a **significant risk**. Political support is needed at a number of levels within the project and is intrinsically linked to a lack of support by directly affected stakeholders. It is possible that, even with targeted activities to inform political representatives about the project and to appropriately deal with stakeholder issues, this risk may cause possible project delays. The project would need to allow project management resources to respond should these incidents occur.
Legal agreements to access land	Commence negotiations before the project is approved. Land valuations conducted so that payment offered is considered reasonable. Ongoing engagement dealing with issues raised by directly affected landholders.	This is considered a **high priority risk** as the threat is considered to be likely even with the control in place. Failure to have appropriate agreements in place has major consequences for the project's delivery. The only control activity identified for managing this risk is the development and implementation of an adequately funded and resourced communications and engagement strategy for dealing with stakeholder issues. However, this is not regarded as an effective option as it remains a high priority risk even with the control in place. Due to the implications for project delivery, review of the effectiveness of this strategy would need to be monitored by the PCB through any ongoing stages of the project.
Lack of certainty regarding liability	Clearly define the roles and responsibilities of all parties and formalise the roles before the project is implemented.	This is considered as a **significant risk**. Whilst this issue is a major concern for all agencies and stakeholders, it can be alleviated to some extent through agreements clearly assigning roles and responsibilities. It is recognised however, that these agreements cannot prevent litigation against any particular agency and, coupled with lack of certainty provided within legislation, the control activity does not reduce the residual risk. Due to the complexity of developing such agreements, it is possible that this would persist as an issue that has implications for the project's implementation. Sufficient time should be allowed to resolve any potential issues prior to the project's implementation phase.

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	Ongoing
Project Management												
Business Case Preparation												
Communications & Engagement												
Stream/Rainfall Gauging	Install	Collect Data		Collect Data					Collect Data			→
Eildon Release Rise & Fall Study	Study	Trial										
Flow Analysis & Modelling												
BoM Flow Forecasting	BoM Service Development			Interface Development		Forecast Provision & Testing			Forecast Provision			→
Operational Model Development												
Flow Event Planning									Actual Release Planning			→
Survey Mid Goulburn Bed Levels												
Water Level Monitoring	Install			Collect Data					Collect data			→
Inundation Mapping												
Building Survey												
Inundation Modelling												
Salinity Impact Assessment												
Avulsion Risk Assessment												
Levees	Detailed Design & Approvals			Construction			Commission		Operate & Maintain			→
Levee Outlets	Detailed Design & Approvals			Construction			Commission		Operate & Maintain			→
Private Land	Data Collection & Negotiation			Negotiation, Easements, Works								
Specialist Activities	Data Collection & Negotiation			Negotiation, Easements, Works								
Public Infrastructure	Data Collection & Negotiation			Negotiation, Easements, Works								

Key	
	thinking, studies / ongoing
	development
	commissioning
	building

Figure 23: Proposed high level implementation plan for the Goulburn Constraints Measure

15. Alignment between this business case and the Phase 2 Guidelines

The Key Evaluation Criteria specified in the Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases (**the Guidelines**) have been addressed in this business case as referenced below by Table 0-1.

Guidelines Section	Heading	Requirement	Business Case Section
4.1	Project details	Key project details and overview	1.3 to 1.6, 2.1 to 2.8, Appendix 1
4.2	Ecological values of the site	Description of the ecological values of the site	3.1 to 3.5, Appendices 2 and 3
4.3	Ecological objectives and targets	Confirm objectives and targets	4.1, Appendix 4
4.4.1	Anticipated ecological benefits	Proposed outcomes from the investment	4.2 to 4.7
4.4.2	Potential adverse ecological impacts	Assessment of potential adverse impacts	Section 5, Appendix 6 and 7
4.5.1	Current hydrology and proposed changes	Clear articulation of current and proposed hydrology	6.1 to 6.4
4.5.2	Environmental water requirements	Water requirements of new inundated areas	6.5, Appendix 5
4.6	Operating regime	Explanation of the role of each operating scenario	Section 7
4.7	Assessment of risks and impacts of the operation of the measure	Assessment of risks and mitigation options	Section 8, Appendix 6 and 7
4.8	Technical feasibility and fitness for purpose	Evidence that the project infrastructure is technically feasible	Section 9
4.9	Complementary actions and interdependencies	Confirm interaction with other initiatives	Section 10
4.10	Costs, Benefits and Funding Arrangements	Detailed costing and listing of benefits	Section 11
4.11.1	Stakeholder management strategy	Confirm stakeholder list and stakeholder management strategy	Section 12
4.11.2	Legal and regulatory requirements	Legal and regulatory requirements	Section 13
4.11.3	Governance and project management	Governance and project management	14.1, 14.3
4.11.4	Risk assessment of Project Development and Delivery	Risks from project development and delivery	14.2, Appendix 6 and 7

Table 0-1: Key Evaluation Criteria addressed

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Appendix 1: Feasibility phase investigations and studies

A number of supporting investigations have been undertaken by consultants for GBCMA and the MDBA to inform the development of the Goulburn business case. The investigations included assessments of river hydrology, floodplain inundation, inundation impacts to public and private land and assets, the identification of possible mitigation activities, costing of possible mitigation activities, regulatory approvals and program implementation and engineering. These projects are summarised in Table A-1.

Table A-1: Projects undertaken

Project	Consultant(s)	Tasks	Sub-tasks	Methods used
Hydrology[2]	Jacobs	Assess the ability to increase unregulated flow events at Shepparton	Collate unregulated flow event data and characterise these events	Collation of historic flow data and analysis
			Investigate potential triggers to commence flow releases	Daily timestep modelling
			Model possible Lake Eildon release scenarios	Daily timestep modelling
Mapping of assets on public and private land	ThinkSpatial	Generate accurate GIS layers locating key asset classes	Realign roads and bridges on existing GIS layer	Analysis of aerial photography and GIS adjustment
			Realign buildings on existing GIS layer and locate additional buildings	
			Map outline of specialist activities	
River bed level survey	Oxley	Survey the river bed level of the Acheron and Yea Rivers		Field survey of stream thalweg
Hydraulic Modelling[1]	Water Technology	Estimate the area of land along the Goulburn River that is inundated at different river flows	Collate topographic data	Data collation and analysis
			Set up GPU 2-D hydraulic model and calibrate.	Hydraulic modelling
			Model flows in river and map land inundated	Hydraulic modelling and GIS analysis
		Assess combined River Murray and Goulburn River flow impact on the area inundated	Model flows in river and map land inundated	Hydraulic modelling and GIS analysis
		Assess the interaction of impact of Goulburn River flows on inundation along the Acheron and Yea Rivers	Collate topographic data	Data collation and analysis
			Set up GPU 2-D hydraulic model.	Hydraulic modelling
			Model flows in river and map land inundated	Hydraulic modelling and GIS analysis
Lower Goulburn levees[1]	Water Technology	Undertake levee risk assessment and mitigation strategy	Undertake risk assessment of levee condition	Risk assessment and GIS analysis
			Prepare risk mitigation strategy and costs to mitigate	Expert analysis
Levee land	Goulburn	Estimate levee land		Estimation

Project	Consultant(s)	Tasks	Sub-tasks	Methods used
acquisition	Broken CMA	rights acquisition cost		
Lower Goulburn levee outlets[1]	GMR Engineering	Develop preliminary concept design and cost to modify levee outlets to retain river flows within levees	Assess condition of each structure	Expert structure inspection
			Review structure design drawings to determine structure design limitations and strengths	Expert review
			Develop preliminary concept designs for each structure and cost structure upgrades	Expert analysis
Private agricultural land	GHD	Refine prefeasibility assessment of impacts on agriculture, and the costs of easements that may be required over the land in light of those impacts	Reassess key assumptions, e.g. land use, land value, impacts, and recalculate costs	Consultation with informed stakeholders (e.g. local agricultural experts)
			Reassess hydrological assumptions, i.e. frequency/timing/duration of flows, and recalculate costs	Use new simplified hydrological assumptions
		Identify and cost works on private infrastructure	Assess where private infrastructure works would be required to complement easements, and estimate costs of those works	Expert analysis
Public infrastructure	AECOM	Refine assessment of public infrastructure (e.g. roads, crossings, bridges, stormwater), how it might be affected by changes in flows, and mitigation options and costs.	Reassess and refine existing GIS-based datasets	Expert analysis
			Consult with regional stakeholders to refine understanding of impacts on specific infrastructure items, and works required	Consult with regional stakeholders
			Estimate costs of infrastructure works and mitigation	Expert analysis
Implementation costs	Jacobs	Assess what processes would be required to implement mitigation measures, and estimate costs of those processes	Stocktake of approval and management requirements relevant to implementing mitigation measures	Expert analysis
			Estimate costs of processes	Expert analysis
Specialist activities	Jacobs	Consider specialist activities (e.g. caravan parks, golf courses, quarries and Murray Shacks), how they might be affected by changes in flows, and mitigation measures and costs	Identify specialist activities which would be affected, and develop methodology for identifying potential impacts and appropriate mitigation measures.	Expert analysis
			Engage with potentially affected businesses and develop story about how affected	Consult with regional stakeholders
			Develop indicative estimates of costs	Expert analysis
Risk	Biogeny	Undertake high level	Develop risk register	Expert analysis

Project	Consultant(s)	Tasks	Sub-tasks	Methods used
Management Strategy		project risk assessment and develop risk mitigation strategy		
			Assess risks and develop mitigation strategies	Expert workshop
Regulatory approvals strategy	DELWP	Develop scope of regulatory approvals required		Expert analysis

(1) Peer review completed

Hydrology

Context and scope

In the pre-feasibility phase, to achieve desirable environmental benefits from constraints management, MDBA used overbank environmental flow recommendations for the desirable frequency of floodplain inundation at flows of 25,000 ML/day and 40,000 ML/day at Shepparton, and for the number of events on average in 10 years to increase from the current frequency to the desired frequency.

To achieve these flows, the concept of adding limited reservoir releases to downstream unregulated tributary flows was proposed in Water Technology (2010c).

Approach to assessing flow management needs and options (feasibility phase)

For the feasibility phase, Jacobs (2015a) examined past unregulated flow events at Shepparton to understand the characteristics of the events that could need to be added to. By routing gauged flows from upstream based on measured regulated flow releases, the source of the water in unregulated flow events at Shepparton was determined. A spreadsheet model was developed using mean daily flow records over the last 55 years (from 1960 to 2014 – i.e. post Lake Eildon construction). Historic diversions to Waranga Basin were assumed to have been ceased, and the diverted flow added back to the Goulburn River downstream.

The unregulated flow events were then characterised to understand the size, timing, sequencing and duration of unregulated flow events.

Constraints to making environmental releases from Lake Eildon were analysed. Travel times for releases from Lake Eildon to reach Shepparton, the limits on allowable rate of rise and fall in releases from Lake Eildon, and constraints from flooding private land downstream of Lake Eildon were considered.

Triggers for releases from Lake Eildon using observed streamflow, observed rainfall, forecast rainfall and forecast streamflow were modelled to determine effectiveness.

Using triggers for release from Lake Eildon based on forecast streamflow and limits on flow at Alexandra (representing a key mid river constraint), the ability to increase flows during unregulated flow events at Shepparton were modelled. The modelling assumed releases were limited to a target flow at Alexandra, with Lake Eildon releases being increased and decreased within appropriate limits. The resultant flows along the river and at Shepparton were then computed. An upper limit on flows at Shepparton was also tested.

The work is fit to understand the key concepts and issues in providing storage flow releases to increase unregulated flows. However, a range of uncertainties existing and the needs for future work to increase understanding and confidence are documented.

Asset mapping

Context and scope

Previous work by Water Technology (2009) mapped the location of wetlands, native vegetation, land use, buildings, and roads and bridges. In Water Technology (2011), public and private land tenure was mapped. This mapping was used in MDBA's pre-feasibility assessment of the Goulburn Constraints project to compare to the floodplain inundation associated with different river flows, to determine the benefits and impacts of the inundation.

Approach to assessing impacts and mitigation options (feasibility phase)

For the feasibility phase, the adequacy of this asset mapping was reviewed. This review identified that the accuracy of locations of buildings was inadequate (including some buildings not being mapped). The location of roads and bridges was also not accurate enough. Inaccuracy means that many assets close to the edge of the water could be listed as inundated when they are not, and vice versa.

In addition, there was no mapping of specialist activities (not considered in previous work).

ThinkSpatial undertook the checking and/or mapping of each of these assets. This was done by comparing the asset layer (buildings, roads and bridges) with recent high resolution aerial photography, shifting assets on the asset layer to line up more precisely with the locations on the aerial photographs, and adding new assets (buildings and specialist activities) onto the asset layers. For specialist activities, the boundary of the key assets were mapped, rather than the property boundary.

Buildings were further subdivided into houses and other, based on an approximate interpretation of roof shape and building configuration.

These new asset maps were then used in other investigation projects in determining which assets were impacted by possible inundation flow footprints.

River Level Survey

Context and scope

To undertake hydraulic modelling of rivers to determine the land inundated at different flows, land elevation data is required. This is generally available through airborne laser scanning. However, airborne laser scanning does not measure land levels under water.

Approach to assessing impacts and mitigation options (feasibility phase)

To model flows in the Acheron and Yea Rivers and their interaction with the Goulburn River, a survey of the thalweg of each river was undertaken using a combination of total station and GNSS methods. The survey picked up bed levels at every 100 m along the stream from Taggerty to the Goulburn River (15 km) on the Acheron River and from Murrundindi Road to the Goulburn River (24 km) on the Yea River. Survey accuracy was +/- 50 mm vertically and +/- 200mm horizontally.

Hydraulic modelling

Context and scope

Hydraulic modelling is used to understand how much of the floodplain is inundated at different river flows. The area inundated is then compared to the location of environmental and economic assets on the floodplain to understand the benefits of floodplain inundation and the impacts of floodplain inundation.

In the pre-feasibility phase, MDBA used hydraulic modelling undertaken by Water Technology (2010a, 2010b) and supplemented it with additional modelling by Water Technology (2014) at different flow rates using the same models. The hydraulic modelling was undertaken in Mike Flood modelling software – a linked 1-D/2-D, CPU based, hydraulic model. Nine models were used to cover the length of the Goulburn River from Lake Eildon to The River Murray. Grid sizes in the 2-D models were 25m x 25m in most models and 60m x 60m in the most downstream model. The accuracy of calibration of the models was quite variable in quality.

Approach to assessing impacts and mitigation options (feasibility phase)

New hydraulic models were developed for the feasibility phase by Water Technology (2015a). The Tuflow 2-D, GPU based hydraulic modelling software was used with grid sizes of 10m x 10m. The smaller grids sizes allowed better identification of smaller topographic features (depressions and channels) important in distributing water on the floodplain.

Two models were developed, one from Lake Eildon to Goulburn Weir and one from Goulburn Weir to the River Murray.

The topographic data used in setting up the models was primarily the same as in the 2010 models, being airborne laser scanning, some river cross-sections, and a thalweg survey from Goulburn Weir to the River Murray (see Water Technology (2010a)). Models were calibrated to 7 existing flow height relationships established at flow measurement sites along the river. In addition, new river water level measurements taken between Lake Eildon and Molesworth at 7,000 and 9,000 ML/day steady flows in November 2011 (Water Technology , 2012) were used to calibrate the mid Goulburn model between the flow gauging sites. A 9,000 ML/day flow is just below bankfull. Further, information gathered during community consultation was used to check and adjust model performance.

The models were run to provide a steady-state flow, and the area of floodplain inundated was determined after steady state had been achieved. This process is not designed to simulate a reservoir release, but rather to determine the level of inundation to any point along the river associated with a particular flow in the river at that point.

However, between Seymour and Goulburn Weir, the new model performed poorly, primarily related to the software not having the capacity to model the flow through Goulburn Weir appropriately. In this reach, the 2010 model results was used in the feasibility phase. Based on community feedback, these results grossly over-estimate the inundation impacts upstream of Goulburn Weir and somewhat under-estimate the inundation impacts closer to Seymour. On balance, the results over-estimate impacts and should therefore be conservative.

Overall, the calibration of the models developed for the feasibility phase is a significant improvement on the pre-feasibility models, particularly between Lake Eildon and Molesworth, and between Goulburn Weir and the River Murray. At a project scale, the model results are fit for assessing the overall benefits and impacts of different flow regimes. They are not accurate at the local property scale.

The areas inundated have then been compared to asset maps prepared by Water Technology in 2010 and by ThinkSpatial in 2015, to determine the assets benefiting from and impacted by inundation associated with different levels of river flow.

The above modelling assumes no flows were occurring from any tributaries to the Goulburn River. As Lake Eildon releases are expected to be added to tributary flows, the inundation modelling does not account for flows backing up tributaries and increasing inundation on the tributary's floodplain. To examine potential interactions between flows in tributaries and in the Goulburn, two models were set up of the lower Acheron River and Goulburn River junction, and of the lower Yea River and Goulburn River junction. The models used a section of the Goulburn model upstream and downstream of the tributary junction. The tributary part of the model were based on available LIDAR data and the thalweg survey undertaken by Oxley, and covered the same extend as the Oxley survey. Models were not calibrated, but used with combinations of low and high Goulburn flows against low and high tributary flows to understand the potential impact of the interaction of flows.

In the steeper streams modelled, little impact on tributary floodplain inundation was seen. However, it could be more significant in the flatter tributaries in the lower Goulburn and needs to be further assessed. While locally important, additional tributary inundation is not expected to be significant at the project scale.

The Goulburn River modelling also assumes only a normal winter flow was occurring in the River Murray. As Goulburn releases are likely to be timed to add to River Murray releases to achieve downstream environmental benefits, the inundation modelling does not account for flows backing up the Murray and Goulburn Rivers from the interaction of these flows. To examine the relative potential interactions, the Goulburn River model was used with different River Murray flows applied at Barmah township. The Murray arm of the model assumes the bed is at the 2001 water level (ie river cross-section below the LIDAR water level were not used), and hence the modelled water levels are much higher than those actually associated with the Barmah flows put in the model. The Murray flows were nominally 5,000 and 22,000 ML/day, added to Goulburn River flows of 25,000, 35,000, 40,000 and 55,000 ML/day. The combined Goulburn and Murray high flows showed significantly increased inundation along both the Murray and the lower Goulburn floodplain compared with low Murray flows. Further work is required on the impacted area and assets of potential combined flows, and associated flow management.

Lower Goulburn levees

Context and scope

Along the lower Goulburn River, from near Loch Garry to the River Murray, a system of levees limits the extent of inundation of the floodplain, protecting farmland from flooding in 4 out of 5 years on average. The condition of the levees to withstand flooding is highly variable. The purpose of increasing river flows under the Goulburn Constraints project is to increase flooding of the floodplain within the levees, not outside the levees. Hence it is important that the levees are in a suitable condition to fulfil this function.

During the CMS prefeasibility phase, Water Technology (2014) estimated the cost of upgrading these levees. This was based on a strategic levee audit in 2013 which defined the defects in current condition. The audit involved a survey along the entire length of the levees, defining the height of the levee at approximately 50 metre intervals, and identifying visual points of weakness in the levee. There was no geotechnical assessment of the levee. Water Technology estimated the cost associated with raising the levee and addressing points of weakness for different river flows. In addition, the costs of strategic levee realignment were estimated, based on realignment projects developed in 2005.

Approach to assessing impacts and mitigation options (feasibility phase)

For the feasibility phase, the same process was repeated using updated criteria and information, and is reported in Water Technology (2015b). The primary source of information was the 2013 levee audit defining current heights and points of weakness.

Revised hydraulic modelling was used to define the water height expected against the levees along their length, and therefore the levee heights required where levee raising was required.

Areas of levee replacement were defined by sections of levee in such poor condition that replacement was preferable to repair.

Areas of levee realignment were redefined to locations where levees were too close to the river and would be subject to the river eroding the bank under the levee in the next approximately 20 to 40 years, and where the levee was in poor condition and realignment would be preferable to replacement.

Where levees were to be realigned or reconstructed, the replacement height was assessed as to be the current height (to provide the existing flood protection during natural events) or the height of the proposed flow buffer, whichever was higher.

Repair of points of weakness were based on a risk assessment. The level of risk varied with the level of river flow. The level of acceptable risk was low, meaning all points of weakness with a higher risk assessment need to be repaired. In addition, any points of weakness with a high or extreme consequence were also deemed to be unacceptable (even with a low risk). One risk (poor tree health) could not be assessed and needs to be considered in the detailed design phase.

What was taken into account in cost estimates

Costs for levee replacement were estimated on recent costs per cubic metre for recent works at Hattah Lakes projects. Estimates assumed appropriate soil was available within 25 km from the site, and earthwork profile was in accordance with Victoria’s levee construction guidelines. A contingency of 50% was applied.

Costs for points of weakness repair assumed unit rates of $5,000 for medium and low risk sites and $25,000 for high and extreme risk sites. A contingency of 100% was applied given the potential variability in sites and the scale of effort required to address these points of weakness.

Costs used in the business case for detailed design, project management, flora and fauna and cultural heritage surveys, and statutory approvals were adjusted based on the Jacobs implementation costs work.

To be reliably able to repair, rebuild and maintain the lengths of levee required to retain the floodplain watering flows, legal access to and over the land on which the levees are located is required. For costing purposes, it is assumed that easements would be acquired over the levees located on private land where water is against the levee, allowing enough width to access along the levees and maintain them. An average rural land value in the area has been used with the length and width of easement required to approximately estimate the value of acquiring the land rights.

Lower Goulburn levee outlets

Context and scope

There are 5 outlets through the lower Goulburn levees carrying water north into the Deep Creek and Wakati Creek systems during overbank river flows. These outlets commence flowing at different river flows, with Deep Creek and Loch Garry having gated structures which are opened at pre-set river flows at Shepparton. Wakati Creek, Hagens Lane and Hancocks Creek outlets have no gates to control flow.

The purpose of increasing river flows under the Goulburn Constraints project is to increase flooding of the floodplain within the levees, not outside the levees. Water flowing outside the levees increases flooding of private land, and loses water which could have produced better inundation of target wetlands and native vegetation further downstream. To avoid this, the levee outlets need to be able to hold flow inside the levees during managed flow events, while allowing water to flow through the levee outlets as they do now under normal flood events.

During the CMS prefeasibility phase, URS (2014) estimated the cost of upgrading these regulators. This included some structural work and the installation of gates on all structures.

Approach to assessing impacts and mitigation options (feasibility phase)

For the feasibility phase, GMR Engineering (2015) reviewed the current condition of all the outlets. Overall, Loch Garry, Deep Creek and Hagen's Lane outlets are structurally sound. Wakati Creek outlet has some cracks and subsidence and is in need of some repair. Hancock Creek outlet pipes are badly cracked, broken and have subsided, and the structure needs to be rebuilt. The four structures which carry significant flow (Loch Garry, Deep Creek, Wakati Creek, Hancock Creek) all had significant erosion downstream of the structure, requiring stabilisation and protection.

The design drawings of the 4 major structures (not Hagen's Lane) were reviewed to understand structural features.

What was taken into account in cost estimates

The designs in GMR Engineering (2015a) used the following criteria:

- Could retain flow at up to 55,000 ML/day flow rate in the Goulburn River (water elevation at each structure determined from hydraulic modelling), and when open pass flow in natural events.
- Gates designed to withstand potential damage from floating logs
- Be able to operate remotely (given the potential need to change operation during a flow event).
- Appropriate access to be provided (some structures in remote locations)

Importantly, the fitting of gates to Deep Creek and Loch Garry in particular reduced the waterway area through the structures, thus reducing the flow during normal flood events when the gates are open. An allowance has been made for providing additional waterway capacity to offset this loss.

Cost estimates have been based on standard engineering costs, including GMW's recent experience with building environmental watering structures. Estimates of cost allowed 40% contingencies on the construction cost estimate, and 18.2% for detailed design, approvals and project management costs. In the business case, the design, approvals and project management costs were replaced by standard costs developed by Jacobs for MDBA.

For the 40,000 ML/day flow buffer in this project, Loch Garry remains closed as it currently does, and needs no upgrading. Hence only the other 4 structures need gates fitted, with a reduced allowance for replacing lost capacity at Deep Creek.

Private agriculture

Context and scope

During the CMS prefeasibility phase, GHD was engaged to investigate and estimate the likely costs associated with ensuring passage of environmental flows over private agricultural land (GHD, 2014a). The prefeasibility study focused primarily on the purchase of easements from landholders, but also looked at other potential arrangements. The principal output of the study was a desktop-based model to calculate the likely magnitude of costs associated with the purchase of easements. The model provides an estimate of how changes to the flow regime might have implications for the *worth of the affected land*[10] as a function of impacts on agricultural activity. The model was applied to a set of different flow scenarios in order to enable comparison between options.

Approach to assessing impacts and mitigation options (feasibility phase)

GHD refined the costing model developed during the prefeasibility phase, by:

1. Peer review and refinement of *agricultural land worth*[11] values. This was done through consultation with qualified rural valuers.
2. Peer review and refinement of agricultural enterprise gross margins and impacts of inundation on productivity. Figures were provided and reviewed by officers from state government departments with primary industry responsibility.
3. Refining and verifying land use classifications for inundated land using satellite imagery. During the prefeasibility phase, GHD had used ACLUM classification at a cadastral level, without ground truthing those classifications. It was acknowledged that this verification process would assist in improving the prefeasibility cost estimate.
4. Updating hydrology assumptions to reflect modelling work undertaken during 2015.

What was taken into account in cost estimates

GHD considered impacts and mitigation options on inundated land and land suffering interrupted access, for the following land use types:

- Grazing tolerant pastures
- Grazing vulnerable pastures
- Cropping
- Horticulture.

Easement costs are assumed to take into account <u>typical</u> impacts and mitigation options as outlined in the tables below.

It should be noted that the feasibility cost estimates are not intended to reflect circumstances for any given property. Costs relevant to individual landholder circumstances would be subject to negotiation during an implementation phase.

Table A-2: Inundated land

Impacts	Mitigation options
Tolerant pastures • Loss of grazing due to flooding. After flood recession, grazing reduced by silt deposition and inability for stock to traverse boggy ground. Measured as number of foregone grazing days • Foregone grazing days increases as duration of	• Provide alternative grazing for livestock for the period of foregone grazing or compensation via purchase of easement • Allow for increased weed control • Allow for starter fertiliser application to stimulate regrowth

[10] *"Worth of affected land"* is calculated as a function of "*agricultural land worth*".
[11] *"Agricultural land worth"* is calculated based on the gross value of production relevant to directly affected land.

Impacts	Mitigation options
inundation increases and also with later season flooding due to reduced chance of follow-up rain to remove silt prior to late spring senescence • Weed infestation • Pastures survive flooding but recovery is delayed unless soil fertility is restored • Deposit of debris eg logs etc on paddocks • Increase in kangaroo numbers (occurs for all land use types)	• Allow for clean-up of debris
Vulnerable pastures As above, but including the need to partially or completely restore pastures due to death of plants	As above except that pasture renovation costs, including complete resowing as a result of a flood may be required. Foregone grazing increases due to time needed for resown pasture to become established before grazing
Crops Yield losses, including complete loss of crop and need to resow if earlier in the season	Recognise both direct costs of losses as well as implications for long term contracts
Livestock husbandry On the assumption that sufficient advanced warning of impending CMS flows is provided, livestock can be moved to land where normal husbandry and marketing operations can proceed	Recognise additional cost of mustering, otherwise no loss of production so long as alternative grazing is available for the foregone grazing days. There is a significant cost in providing alternative grazing sources, whether these are available on farm or via agistment.
Fencing Flows can potentially damage fences due to a build-up of debris and reduction in longevity due to additional flooding of posts and wires	Recognise the costs to restore fences – removal of debris, straightening posts, restraining There may be limited opportunity to relocate fences to avoid flood damage and at the same time improve livestock management
Bridges and crossings Approaches and abutments can be eroded and reduce access.	Recognise ongoing costs for repairs and maintenance

Table A-3: Interrupted access land

Impacts	Mitigation options
Pastures Loss of grazing on the assumption that livestock are removed to "safe" land to ensure continuity of husbandry and marketing options Nil impact on pasture quality and density if interrupted access is for short periods only	Provide alternative grazing for livestock for the period of foregone grazing or compensation via purchase of easement Consider cost-benefit of constructing new bridges or crossings that could enable access to be maintained at the flows proposed
Crops Delayed harvesting or husbandry procedure (eg spraying) could reduce both yield and quality See pumps for irrigation below	If access is not upgraded (see below), recognise yield and quality reductions in easement costings Consider cost-benefit of constructing new bridges or crossings that could enable access to be maintained at the flows being proposed
Bridges and crossings (existing) Inundated for varying periods of time	Consider cost-benefit of refurbishing existing bridges or crossings that could enable access to be maintained at the flows being proposed
Pumps	See above with respect to access

Pumps that supply both irrigation and stock and domestic water supplies may become isolated	Consider cost-benefit of raising pumps above flood height, but this unlikely to remove risk unless access is also resolved

The estimated cost includes land value, the cost to negotiate easements, and the cost for on-ground works. A contingency of 10 percent has been built into the easement costs. Estimates are considered fit for purpose at regional level but not at a more local scale. A $5,000 “administration” cost has been assumed per property, based on experience in negotiating easements in the Hume-Yarrawonga and Mitta Mitta reaches. This is expected to be too low for the Goulburn and some additional costs are allowed under the communications and engagement program.

In the context of the timeframes available for the feasibility work, and associated constraints to on-ground consultation with landowners, it was not possible to identify precisely which private crossings would require infrastructure works. The number of private crossings, and the nature of works required, has been estimated on a regional basis, drawing on intelligence gathered from sample “case study” properties. Estimates are considered fit for purpose at regional level but not at a more local scale. A contingency ranging from 50 to 160 percent has been built in. The business case has used the high cost (or P90) estimate. Estimates are considered more likely to be overestimates than underestimates.

Public infrastructure

Context and scope

During the CMS prefeasibility phase, URS engineering consultants were engaged to investigate the costs associated with potential infrastructure works to mitigate the impacts of higher environmental flows – for example, works on roads or river crossings (URS , 2014).

URS developed a desktop-based model which assumed that “unit rates” could be used to estimate the costs of infrastructure work. Desktop-based GIS analysis was used to identify what infrastructure would potentially be affected, through assessment of the intersections between GIS-based infrastructure datasets, and modelled inundation maps at different flow rates. URS also assessed the costs associated with a small selection of specified larger infrastructure items.

In 2015 AECOM was engaged to undertake work during the CMS feasibility phase, to build on and refine the assessment undertaken by URS in 2014 (AECOM, 2015). AECOM undertook this work in the following key focus areas: Hume-Yarrawonga, Yarrawonga-Wakool, River Murray in South Australia, Murrumbidgee, and Goulburn.

Note that AECOM considered only public[12] infrastructure. Infrastructure on private agricultural land was considered separately by GHD through the private agriculture project.

Approach to assessing impacts and mitigation options

AECOM refined the prefeasibility costing work by:

- Creating a spatial (GIS) database of available information

[12] For the purposes of this project “public infrastructure” included:
- transport infrastructure (e.g. roads, crossings, bridges) which is owned or maintained by governments (e.g. local councils)
- stormwater and sewerage infrastructure which is owned or maintained by local councils
- levees which are owned or maintained by local councils and which are used to help manage the effects of higher river levels and/or significant rainfall events
- river operation infrastructure (e.g. locks, weirs, floodgates, regulators) which are publicly owned or maintained
- irrigation infrastructure (e.g. irrigation channels, drainage canals) which is owned or maintained by corporate entities (e.g. irrigation companies), even where those corporate entities are privately owned and operated (e.g. Murray Irrigation Limited).

Similar infrastructure which is owned or maintained by agricultural landowners (e.g. roads, crossings, bridges, levees on private agricultural land, private irrigation pumps) was outside the scope of this project.

- Identifying assets at risk, in consultation with regional stakeholders
- Developing responses/treatments for assets at risk
- Preparing an estimate of probable cost for response/treatment measures
- Undertaking an assessment of the total cost for each reach

A key element of the project was working with on-ground stakeholders to ground truth assumptions and modelled inundation outcomes of infrastructure that would be affected at the specified flow rates. AECOM engaged with local councils through a combination of phone calls and regional visits.

What was taken into account in cost estimates

During their consultations with local Councils and other public asset managers, AECOM found that:

- Substantial capital upgrade works would not be typically required to mitigate against environmental flows. Councils identified that the most efficient approach to mitigate environmental flows is to proactively manage, or directly respond to the impacts of the events. A small number of exceptions for assets requiring upgrade were identified and recorded.
- Very few culverts or bridges require physical repair/replacement after flow events. The typical response was clean up of silt and debris and reinstatement of beaching where materials had been washed away.
- Roads subject to inundation or even water to the road shoulder would not necessarily require works, but experienced greater rates of deterioration in the months after flows.
- Operational costs to enact flood mitigation controls (such as road management/closing and shutting off backflow prevention valves) was a common cost, not captured by asset costing.
- Duration of inundation extending beyond seven days has an amplified impact on damage and costs. The impacts of this have been considered in proposed treatment measures and associated costs, and separate calculations prepared for each outcome.
- Landscaped areas (including manicured grassed parks and sports fields) require rectification.
- Waterside infrastructure (such as jetties, pontoons, boardwalks) often require maintenance and repair.

AECOM considered the following mitigation responses, in developing cost estimates:.

Table A-4: Mitigation options for different asset classes

Asset Class	Definition / Description	Response

Sealed Road	Sealed roads are typically any roads that have a bound surface finish – primarily asphalt but may also include concrete.
	- Non-LGA:
	  - Road classes with a Major (Assumed Freeway or Highway – State owned) classification and sealed surface.
	  - Any sealed road that are within National or State Forests, or reserves that are not owned or maintained by an LGA.
	- LGA:
	Any sealed road with Arterial, Sub-arterial, or Local classification that are owned or maintained by an LGA.
		Pavement Rehabilitation
		or
		Intermittent pothole rectification.

Asset Class	Definition / Description	Response
Unsealed Road	Unsealed roads are typically roads that are used for regular access to properties or assets, which have a formed earth material pavement (typically crushed rock or other compacted granular material) – to a defined engineering standard. - Non-LGA: • Any unsealed road with Arterial, Sub-arterial, or Local classification that are within National or State Forests, or reserves that are not owned or maintained by an LGA. - LGA: Any unsealed road with Arterial, Sub-arterial, or Local classification that are owned or maintained by an LGA.	Road regraded with crushed rock supplement or Road regraded only
Track	Tracks are typically assets which are used for infrequent access to sites or for recreational use (4WD etc.), which are of suitable dimensions for vehicle access but possibly not to a defined engineering standard. - Non-LGA: • Any road with a Track classification that are within National or State Forests, or reserves that are not owned or maintained by an LGA. - LGA: Any road with a Track classification that is owned or maintained by an LGA.	Ad-hoc maintenance allowance. Repair to be applied at damaged locations only. Typical costs averaged to achieve km cost rate.
Shared Path / Walking Track	Shared path/walking tracks are typically defined paths that are for recreational use, but have not been designed for vehicle access. - Non-LGA: • Any road with a Recreational classification that are within National or State Forests, or reserves that are not owned or maintained by an LGA. - LGA: Any road with a Recreational classification that are owned or maintained by an LGA.	Earth Material track surface repair.
Bridge	Any bridge which may be associated with LGA and Non-LGA roads.	Bridge replacement – per identified item, or Silt / debris removal and rock abutment reinstatement
Culverts	Typically a pipe structure that allows water to flow under a road. It may be associated with LGA and Non-LGA roads.	Culvert replacement, End wall reinstatement, or Silt / debris removal and rock beaching reinstatement
Fords	A low area along a river or stream that is used as a crossing, but designed for inundation/overspill in high flow events. May be associated with LGA and Non-LGA.	Grading and removal of debris.

Asset Class	Definition / Description	Response
Landscaped Area	Grassed areas such as parks and sports fields which require rehabilitation after periods of inundation. These were identified using the land use planning zones of "Public Open Space" (Victoria) or "Parks and Reserves" (NSW). Treatments to apply to manicured (regularly mowed and actively used) landscape only.	Silt /debris removal only. Applied to 10% of identified Open Space, or Silt removal and re-seeding. Applied to 10% of identified Open Space.

AECOM also considered a number of potential infrastructure items which would require capital works, which were identified during the stakeholder consultations.

Table A-5: Infrastructure items requiring capital works

Capital Cost Item	LGA
Isolated Property Access. (This item makes provision for upgrades to key access roads to properties which would otherwise be isolated during a high flow event).	All
Stewarts Bridge Road	

AECOM also utilised a number of datasets as part of their analysis:

- Collaboration between Goulburn Broken Catchment Management Authority and Water Technology 2015, Flow inundation modelling (for Eildon to Killingworth, Killingworth to Goulburn Weir, and Downstream of Goulburn Weir)
- Digitised Point crossings, NSW LPI Digital Topographic Database, 2014
- Point Crossings, VICMAP, 2014
- Roads on private land and public land, NSW LPI, 2014
- Roads on private land and public land, Victoria DELWP, 2014 (adjusted by ThinkSpatial)
- NSW LPI 2014 Cadastre of Public land
- VICMAP 2014 Crown land Public Land Management (PLM25), Victoria DELWP
- River Murray Water Main Structures and Hydrologic Indicators sites, MDBA 2008.

Cost estimates are considered "prefeasibility" in terms of accuracy. A contingency of 15 to 60 percent has been built in to the base cost estimates. A further 12 to 160 percent contingency has been added to cover potential additional implementation costs. Some changes to public infrastructure were identified in the Specialist Activities work, and they have been added to the public infrastructure costs in the business case. The business case has used the high cost (or P90) estimate. Estimates are considered more likely to be overestimates than underestimates.

Specialist activities

Context and scope

During the CMS prefeasibility phase, some potential costs were not estimated. This included potential costs associated with mitigating impacts on Specialist Activities.[13] Instead, the nature of these impacts was assessed qualitatively (refer to Table 7 of the 2014 Cost Estimates report).

The CMS prefeasibility phase considered the potential impacts on river shacks in South Australia through a separate exercise undertaken by GHD.

[13] Broadly defined as land-uses and activities that are not related to broad-scale agriculture or major public infrastructure.

Jacobs and RMCG (hereafter referred to as Jacobs) were engaged to inform the CMS feasibility phase by undertaking a more detailed assessment of potential impacts on specialist activities (including river shacks). Table 1 lists the type of activities considered. Jacobs undertook this work in the Hume-Yarrawonga, Yarrawonga-Wakool, River Murray in South Australia, Murrumbidgee and Goulburn reaches.

Table A-6: Scope of specialist activities

Activity	Activity type	In/Out of Scope
Residential Activity (including River shacks)	Residential activity	In scope
Tourist cabins	Tourism activity	In scope
Caravan park	Tourism activity	In scope
Holiday accommodation	Tourism activity	In scope
Golf course	Recreation activity	In scope
Public park	Recreation activity	Out of scope (considered through separate public infrastructure project undertaken by AECOM)
Wineries	Other Primary Industry	In scope
Orchard (*Irrigated modified pastures, perennial tree fruits, perennial vine fruits*)	Other Primary Industry	Out of scope (considered through separate private agriculture project undertaken by GHD)
Turf farms	Other Primary Industry	In scope
Dairies	Other Primary Industry	Out of scope (considered through separate private agriculture project undertaken by GHD)
Nurseries	Other Primary Industry	In scope
Quarries	Other Primary Industry	In scope
Aquaculture	Other Primary Industry	In scope
Forestry	Other Primary Industry	In scope
House boat operators	River based business activities	In scope
Outdoor adventure tourist operators	River based business activities	In scope where CMS impacts on fixed assets

Approach to assessing impacts and mitigation options

Jacobs created a spatial (GIS) data base of available information to identify the type, number and location of affected specialist activities in the reach.

Jacobs assessed impacts, mitigation options and costs through two complementary processes of case studies and cost assessment and extrapolation.

Case Studies

Jacobs worked with stakeholders through selected case studies, to “ground truth” assumptions and modelled inundation outcomes (Table 2). The consultants engaged through a combination of phone calls and regional visits to:

- discuss possible impacts from the anticipated flow events
- obtain business data with which to build business cost models
- discuss other similar businesses in the region, and whether the landholder being interviewed thought they would be impacted to a similar degree
- explore possible mitigation options
- view the site, and refine mitigation option concepts.

Table A-7: List of specialist activities case study sites

Reach	Case Studies
Yarrawonga Wakool	Golf course, NSW
	Caravan park, NSW
	Forestry Operation, NSW
Murrumbidgee	Quarry, NSW
Hume to Yarrawonga	Visitors Centre, NSW
Goulburn	Caravan park, Victoria
	Aquaculture business, Victoria
	Caravan park, Victoria
South Australia	River Murray Shacks, South Australia

Cost Assessment and Extrapolation

Daily rate business losses were estimated based on case study data. Where available, data was used from case study sites visited during the community engagement phase of the project. Where sites were of an activity type that differed from the visited sites, desktop case studies were conducted. Desktop case studies included phone calls and searches of the internet for publically available data such as annual reports.

The metrics were selected so that they could be applied by reference to aerial imagery. For instance, for caravan parks:

- the loss per day in the event of a total closure of the park, for example if the access road were inundated; and
- the loss in the event of a partial closure, measured in $/cabin per day or $/campsite per day.
- In each case, impacts were calculated per day that the asset was unavailable, so that changes in average inundation event length would result in changes to the loss calculations.

The number of days for business to resume after inundation was assumed to vary by site. Default durations applied were:

- Quarries 60 days, due to groundwater issues
- Caravan parks 7 days, assuming cabins are not damaged
- Abattoir/factory 3 days, based on minor level of inundation
- Club (football) 7 days, assuming fairly bare club houses, and oval ok after flooding
- Turf farm 0 days, as damaged turf was assumed to be scrapped and compensated
- Cellar door 21 days, as indoor areas and decorations may need tradespeople availability
- Shacks 21 days, as owners typically are offsite, and would take time to arrange repairs
- Forestry 90 days, as waterlogged floodplain is expected to impede heavy vehicle access from Spring – Summer
- Houseboat marina and slipway 7 days, as access should be restored once the river recedes, but it may take a few days for tourists or boat users to check current information
- Residential 21 days, as indoor areas and decorations may need tradespeople availability.

In each case, sites which would experience greater or lesser inundation impacts were assumed to have longer or shorter recovery periods. For example, a quarry site experiencing only a cut access road would be expected to be operating within a week of inundation subsiding (assuming the road did not require rebuilding).

Jacobs considered mitigation measures in the context of two scenarios: an “easement focused” scenario, and an “infrastructure focused” scenario.

Table A-8: Description of easement focussed and infrastructure focussed scenarios

Option	Description
Easement focus	In this scenario, the cheapest mitigation option was selected for each site. This scenario favoured easements as the primary method of mitigating impacts.
Infrastructure focus	In this scenario, infrastructure options were selected if available, in an attempt to minimise the number of easements. Total costs were higher for this scenario than for the easement focus scenario. A number of sites still required easements in this scenario as infrastructure was not suitable for mitigating all impacts. Examples include river shacks build directly on river banks where there is no room to construct a levee.

In assessing the costs associated with an easement focused scenario, Jacobs considered business impacts and a range of other impacts.

Table A-9: Common factors considered in easement price

Mitigation Option	Description
Repair of quarry levees	Levees assumed to be in place but constructed from local materials by quarry operators rather than engineered levees constructed from imported material, and so easily damaged in large flow events
Clean up of inundated buildings	Included only when evidence existed that the building was not raised on stilts, as most flood plain construction is raised
Outdoor clean up	Applied to all sites which would experience inundation of part of the property, other than in undeveloped scrub or forest
Turf repair	Applied to activities which have clean lawn areas, where that lawn is likely to be important to the operation of the activity
Repair access track	Applied to dirt access tracks, assuming that a portion of tracks would require regrading after inundation
Repair of quarry levees	Levees assumed to be in place but constructed from local materials by quarry operators rather than engineered levees constructed from imported material, and so easily damaged in large flow events
Business Losses	Interruption of usual business activities

In assessing the costs associated with an infrastructure focused scenario, Jacobs considered the following possible infrastructure mitigation measures.

Table A-10: Common infrastructure mitigation options for specialist activities

Mitigation Option	Description
Construction of new levees	Appropriate where flood waters spill onto the site through one side of the site, and infrastructure is not directly on the river bank. In some cases levee construction would require installation of stormwater drainage systems to release stormwater from the leveed area.
Armouring existing quarry levees with geofabric material	Tying down existing materials to prevent embankment toe erosion, rather than rebuilding the whole levee.
Raising access tracks / roads	Where existing tracks would be inundated, these could be raised above the flood height, allowing access to property. Tracks were assumed to remain constructed of the current materials, whether dirt, or bitumen. Where necessary, bridge construction was included.
Unique solutions for	Such as moving a shed out of the potentially inundated area, purchase of

Mitigation Option	Description
individual sites	additional tree harvesters to allow stockpiling of material, or lifting a weatherboard house onto stilts

What was taken into account in cost estimates

Jacobs used the following information / data to assess impact and mitigation options and costs for this project:

- Modelled flow and inundation extents provided by the MDBA, and State authorities.
- Aerial imagery.
- Property boundary data sourced from various State authorities.
- Unit rate construction costs obtained from Rawlinson's Australian Construction Handbook 2014 (Rawlinsons).
- Refined unit rate for construction costs were identified at specific case study sites and applied to extrapolations (only where appropriate).
- Business profit and turnover data obtained from case study landholders.
- ABS business statistics.

Estimates are considered fit for purpose at regional level but not at a more local scale, or for individual activities (or categories of activity). A contingency of 100 percent has been built in to base cost estimates. A further 5 to 100 percent contingency has been added to cover potential additional implementation costs. Some changes to public infrastructure were identified in the Specialist Activities work, and they have been removed from Specialist Activities and added to the public infrastructure costs in the business case. The business case has used the high cost (or P90) estimate. Estimates are considered more likely to be overestimates than underestimates.

Risk Management Strategy

Context and scope

With the scale and complexity of the Goulburn Constraints Measure, an initial, high level risk assessment was undertaken to identify significant environmental, social and economic risks and consider how they could be reduced (Tranter, 2015). The risk assessment was undertaken in accordance with the Phase 2 Assessment Guidelines for Supply and Constraints Business Cases. The assessment was based on currently available information and was undertaken early in the business case development, and hence does not focus specifically on all of the findings in the final business case.

Approach to assessing impacts and mitigation options (feasibility phase)

Assessments were based on assessments of similar activities in supply measure business cases, and augmented by specialist advice. A workshop of key agency stakeholders then reviewed the risks and their assessment in the risk register and the proposed mitigation actions.

Regulatory approvals strategy

Context and scope

The Goulburn Constraints Management Business case defines the broad scope of what would be involved in reducing constraints to higher environmental flows. The regulatory approvals strategy (DELWP, 2015) therefore maps out the broad approvals pathway required for the project under Commonwealth and State legislation. It identifies the approvals likely to be required for the project and the associated supporting documentation. It does not address specific construction issues for example.

Approach to assessing impacts and mitigation options (feasibility phase)

Assessments were based on assessments of similar activities in supply measure business cases, and augmented by specialist advice from key agency stakeholders.

Appendix 2: Flood dependent EVCs on the Goulburn River floodplain

EVC #	EVC Name	Bioregional conservation status		Targeted for watering
		Murray fans	Victorian Riverina	
MID GOULBURN (taken from NV2005EVC layer – Arc GIS)				
WETLAND EVCs				
932	Wet Verge Sedgeland	-	-	.
168	Drainage Line Aggregate	Vulnerable	Endangered	Yes
1022	Drainage Line Aggregate/ Riverine Swamp Forest Mosaic	Vulnerable	Endangered	Yes
334	Billabong Wetland Aggregate	Depleted	Vulnerable	Yes
172	Floodplain Wetland Aggregate	Depleted	Vulnerable	Yes
804	Rushy Riverine Swamp	Depleted	Depleted	Yes
1090	Tall Marsh/ Open Water Mosaic	Least Concern	Depleted	Yes
1081	Spike-sedge Wetland/ Tall Marsh Mosaic	Vulnerable	Vulnerable	Yes
810	Floodway Pond Herbland	Depleted	Vulnerable	Yes
74	Wetland Formation	Endangered	Endangered	No[14]
125	Plains Grassy Wetland	Endangered	Endangered	No[1]
FLOODPLAIN EVCs				
295	Riverine Grassy Woodland	Vulnerable	Vulnerable	Yes
871	Riverine Grassy Woodland/ Plains Woodland/ Gilgai Wetland Complex	Depleted	NA	Yes
1040	Riverine Grassy Woodland/ Riverine Swampy Woodland Mosaic	Vulnerable	Endangered	Yes
56	Floodplain Riparian Woodland	Depleted	Vulnerable	Yes
1035	Floodplain Riparian Woodland/ Sedgy Riverine Forest Mosaic	Depleted	Vulnerable	Yes
816	Sedgy Riverine Forest	Depleted	Vulnerable	Yes
815	Riverine Swampy Woodland	Vulnerable	Vulnerable	Yes
1099	Riverine Swampy Woodland/ Plains Grassy Wetland Mosaic	Endangered	NA	Yes
814	Riverine Swamp Forest	Depleted	Depleted	Yes
1068	Riverine Swamp Forest/ Sedgy Riverine Forest Mosaic	Depleted	Vulnerable	Yes
68	Creekline Grassy Woodland	Endangered	Endangered	Yes
106	Grassy Riverine Forest	Depleted	Depleted	No
823	Lignum Swampy Woodland	Vulnerable	Vulnerable	No

[14] Major extent of EVC is outside the maximum floodplain inundation area of 60,000 ML/d

EVC #	EVC Name	Bioregional conservation status		Targeted for watering
		Murray fans	Victorian Riverina	
LOWER GOULBURN (taken from Cottingham et al., 2011)				
WETLAND EVCs				
992	Water body – fresh	NA	NA	No[15]
168	Drainage Line Aggregate	Vulnerable	Endangered	Yes
1022	Drainage Line Aggregate/ Riverine Swamp Forest Mosaic	Vulnerable	Endangered	Yes
334	Billabong Wetland Aggregate	Depleted	Vulnerable	Yes
172	Floodplain Wetland Aggregate	Depleted	Vulnerable	Yes
804	Rushy Riverine Swamp	Depleted	Depleted	Yes
1090	Tall Marsh/ Open Water Mosaic	Least Concern	Depleted	Yes
1081	Spike-sedge Wetland/ Tall Marsh Mosaic	Vulnerable	Vulnerable	Yes
810	Floodway Pond Herbland	Depleted	Vulnerable	Yes
74	Wetland Formation	Endangered	Endangered	No[1]
125	Plains Grassy Wetland	Endangered	Endangered	No[1]
FLOODPLAIN EVCs				
295	Riverine Grassy Woodland	Vulnerable	Vulnerable	Yes
871	Riverine Grassy Woodland/ Plains Woodland/ Gilgai Wetland Complex	Depleted	NA	Yes
1040	Riverine Grassy Woodland/ Riverine Swampy Woodland Mosaic	Vulnerable	Endangered	Yes
56	Floodplain Riparian Woodland	Depleted	Vulnerable	Yes
1035	Floodplain Riparian Woodland/ Sedgy Riverine Forest Mosaic	Depleted	Vulnerable	Yes
816	Sedgy Riverine Forest	Depleted	Vulnerable	Yes
815	Riverine Swampy Woodland	Vulnerable	Vulnerable	Yes
1099	Riverine Swampy Woodland/ Plains Grassy Wetland Mosaic	Endangered	NA	Yes
814	Riverine Swamp Forest	Depleted	Depleted	Yes
1068	Riverine Swamp Forest/ Sedgy Riverine Forest Mosaic	Depleted	Vulnerable	Yes
68	Creekline Grassy Woodland	Endangered	Endangered	Yes
106	Grassy Riverine Forest	Depleted	Depleted	No[1]
823	Lignum Swampy Woodland	Vulnerable	Vulnerable	No[1]

[15] no native vegetation recorded

Appendix 3: Listed species on the Goulburn River floodplain

Data extracted from Assessment of environmental water requirements for the proposed '*Basin Plan: Lower Goulburn River Floodplain'* (MDBA, 2012); '*Lower Goulburn Wetlands Flora and Fauna Surveys'* (Cook, 2012a); '*Mid Goulburn Wetlands Flora and Fauna Surveys'* (Cook, 2012b).

Species	Recognised in international agreement(s)1	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)	Flora and Fauna Guarantee Act 1998 (VIC)
AMPHIBIANS AND REPTILES			
Lace goanna (*Varanus varius*)[4]			V
Brown toadlet (*Pseudophryne bibronii*)[4]			E
Southern bell or growling grass frog (*Litoria raniformis*)[4]		V	E
BIRDS			
Australasian bittern (*Botaurus poiciloptilus*)[2, 3]			E
Australasian shoveler (*Anas rhynchotis*)[4]			V
Baillon's crake (*Porzana pusilla*)[2, 3]			V
Barking owl (*Ninox connivens*)[2, 3]			E
Bush stone-curlew (*Burhinus grallarius*)[2, 3]			E
Diamond firetail (*Stagonopleura guttata*)[4]			NT
Eastern great egret (*Ardea modesta*)[2, 3]	J, C		V
Freckled duck (*Stictonetta naevosa*)[4]			E
Glossy ibis (*Plegadis falcinellus*)	C		
Grey-crown babbler (*Pomatostomus temporalis)*			E
Ground cuckoo-shrike (*Coracina maxima*)[2, 3]			V
Hardhead (*Aythya australis*)[4]			V
Intermediate egret (*Ardea intermedia*)[4]			CE
Latham's snipe (*Gallinago hardwickii*)[2, 3]	J,C,R		
Lewin's rail (*Lewinia pectoralis*)[2, 3]			V
Little bittern (*Ixobrychus dubius*)[2, 3]			E
Magpie goose (*Anseranas semipalmata*)[2, 3]			NT
Marsh sandpiper (*Tringa stagnatilis*)	J,C,R		
Musk duck (*Biziura lobata*)[4]			V
Painted honeyeater (*Grantiella picta*)[2, 3]			V
Rainbow bee-eater (*Merops ornatus*)	J		

Species	Recognised in international agreement(s)1	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)	Flora and Fauna Guarantee Act 1998 (VIC)
Royal spoonbill (*Platalea regia*)[4]			V
Sharp-tailed Sandpiper (*Calidris acuminata*)	J,C,R		
Superb parrot (*Polytelis swainsonii*)[2, 3]		V	E
Swift parrot (*Lathamus discolor*)[2, 3]		E	E
Turquoise parrot (*Neophema pulchella*)[2, 3]			NT
White-bellied sea eagle (*Haliaeetus leucogaster*)[2, 3]	C		V
FISH			
Barred galaxias (*Galaxias fuscus*)[2, 3]		E	CE
Flat-headed galaxias (*Galaxias rostratus*)[4]			V
Freshwater catfish (*Tandanus tandanus*)[2, 3]			E
Macquarie perch (*Macquaria australasica*)[2, 3]		E	E
Murray cod (*Maccullochella peelii peelii*)[2, 3]		V	E
Murray–Darling rainbowfish (*Melanotaenia fluviatilis*)[2, 3]			DD
Silver perch (*Bidyanus bidyanus*)[2, 3]			CE
Trout cod (*Maccullochella macquariensis*)[2, 3]		E	CE
Unspecked hardyhead (*Craterocephalus stercusmuscarum*)			DD
MAMMALS			
Squirrel glider (*Petaurus norfolcensis*)[2, 3]			E
Brush-tailed phascogale (*Phascogale tapoatafa*)[2, 3]			V
FLORA			
Grey billy-buttons (*Craspedia canens*)[4]			E
Jericho wire-grass (*Aristida jerichoensis* var. *subspinulifera*)[4]			E
Western water-starwort (*Callitriche cyclocarpa*)[4]			V
River swamp wallaby-grass (*Amphibromus fluitans*)		V	
Small scurf pea (*Cullen parvum*)		E	L

CE = critically endangered DD = data deficient E = endangered L = listed NT = near threatened V = vulnerable

1 Japan–Australia Migratory Bird Agreement, China–Australia Migratory Bird Agreement, or Republic of Korea – Australia Migratory Bird Agreement

2 Victorian Department of Primary Industries (2010)

3 Department of the Environment, Water, Heritage and the Arts (2009)

4 Department of Sustainability and Environment (2009)

Appendix 4: Link between ecological values and objectives

ECOLOGICAL VALUE	OVERACRHING OBJECTIVES	ECOLOGICAL OBJECTIVES	NESTED ECOLOGICAL OBJECTIVES
BASEFLOW			
• **Macroinvertebrate** • **Native vegetation** • **Native fish**	• 1 • 2 • 3 • 6	• Wet and maintain riffles for macroinvertebrates and small bodied fish, maintain wetted perimeter and aquatic vegetation • Provide suitable in channel habitat for all life stages. • Provide habitat and food source for macroinvertebrates by submerging snag habitat within the euphotic zone	• Scour fine sediment from gravel bed and riffle substrate • Maintain existing beds of in-channel vegetation • Provide slow shallow habitat required for larvae/juvenile recruitment and adult habitat for small bodied fish • Provide deep water habitat for large bodied fish • Provide conditions suitable for aquatic vegetation, which provides habitat for macroinvertebrate • Provide slack water habitat favourable for planktonic production (food source) and habitat for macroinvertebrate • Entrain litter packs available as food/habitat source for macroinvertebrate • Maintain water quality suitable for macroinvertebrate
BASEFLOW/FRESH			
• **Geomorphology**	• 4 • 5	• Maintain pool depth	• Maintain natural rates of sediment deposition
FRESH			
• **Geomorphology** • **Macroinvertebrate** • **Native fish** • **Native vegetation**	All	• Scour fine sediments from riffle surfaces to maintain invertebrate habitat • Maintain habitat for macrophytes • Sloughing filamentous algae and refreshing biofilms • Maintain areas of riffle habitat • Provide flows to promote large bodied endangered species colonisation • Initiate spawning, pre-spawning migrations and recruitment of native fish (preferably late spring early summer for native fish) • Remove terrestrial vegetation and re-establish amphibious vegetation	• Macroinvertebrate provides food source for fish • Mobilise sediments • Increase flow variability to more closely mimic natural hydrological regime • Promote Macquarie perch spawning • Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat

<table>
<tr><th>ECOLOGICAL VALUE</th><th>OVERACRHING OBJECTIVES</th><th>ECOLOGICAL OBJECTIVES</th><th>NESTED ECOLOGICAL OBJECTIVES</th></tr>
<tr><td colspan="4">BANK-FULL</td></tr>
<tr><td>• Geomorphology
• Native fish
• Native vegetation
• Macroinvertebrate</td><td>• All</td><td>• Maintain channel form and key habitats (including in channel benches)
• Maintain bed diversity
• Provide flows to increase native fish recruitment and colonisation
• Provide periodic opportunities for regeneration of riparian and floodplain species and improve in channel carbon availability
• Retain natural seasonality to ensure synchronicity of life cycle of macroinvertebrates</td><td>• Overturn bed substrate
• Maintain channel form and key habitats
• Maintain riffle habitat for macroinvertebrates
• Maintain or increase connection to warmer water
• Maintain channel connectivity to tributaries
• Scour sediments from base of pools to maintain quantity and quality of habitat
• Maintain channel and inlet for connectivity to main channel with floodplain and wetlands
• Promote colonisation by large bodied endangered species
• Provision of lateral connectivity for habitat and production</td></tr>
<tr><td colspan="4">OVERBANK</td></tr>
<tr><td>• Geomorphology
• Native fish
• Native vegetation
• Macroinvertebrate</td><td>• All</td><td>• Maintain channel form
• Maintain connectivity to floodplain and wetlands
• Provide floodplain connection for exchange of organic matter
• Provide periodic regeneration opportunities for native floodplain wetland plants
• Increase the extent and diversity of flood dependent vegetation communities, including higher floodplain areas</td><td>• Maintain diversity among low lying wetlands
• Promote colonisation by large bodied endangered species
• Overturn of bed material and maintain benches
• Provide lateral connectivity as habitat and recruitment areas for native fish
• Provide habitat for wetland specialist fish
• Exchange of food and organic material between the floodplain and channel to improve in channel carbon availability
• Increase breeding and feeding opportunities for native fish, waterbirds and amphibians</td></tr>
<tr><td colspan="4">RATE OF RISE AND FALL</td></tr>
<tr><td rowspan="2">• Native fish
• Macroinvertebrate
• Geomorphology</td><td rowspan="2">• 1
• 3
• 4
• 5</td><td colspan="2">Manage rate of rise to reduce displacement of macroinvertebrates and small/juvenile fish</td></tr>
<tr><td colspan="2">Manage rate of fall to reduce bank slumping/erosion and stranding of macroinvertebrates and small/juvenile fish</td></tr>
</table>

Appendix 5: Environmental flow recommendations for the Goulburn River

Reach	Flow Component	Flow (ML/DAY)	Duration	Season	Ecological Value	Overarching Ecological Objectives	Ecological Objectives	Report
4 - 5	Baseflow	320 - 540	All year	All	• Native fish	• 1	• Provide suitable in channel habitat for all life stages.	2007
4 – 5	Baseflow	830 - 940	All year	All	• Macroinvertebrate	• 3 • 6	• Provide habitat and food source for macroinvertebrates by submerging snag habitat within the euphotic zone • Entrain litter packs available as food/habitat source for macroinvertebrate • Maintain water quality suitable for macroinvertebrate	2007
4 – 5	Baseflow/fresh	Ranging from 856 – 6,060	< 90 days	Summer	• Geomorphology	• 4 • 5	• Maintain pool depth and natural rates of sediment deposition	2007
4 – 5	Fresh	5600	2-4 days 1-4 events a year	Spring Summer	• Native fish	• 1 • 2 • 3	• Initiate spawning of golden perch, migrations of Murray cod and silver perch and recruitment of other native fish (preferably late spring /early summer) • Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat	2010
4 – 5	Fresh	5600	2-4 days 1-4 events a year	Summer Autumn	• Native vegetation	• 2 • 3	• Establish amphibious and lower bank vegetation • Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat	2010

4 – 5	Fresh	5600	14 days 1-4 events a year	Winter Spring	• Native vegetation	• 2	• Remove terrestrial vegetation and re-establish amphibious and lower bank vegetation	2010
4	Overbank*	25 000	5+ days 2-3 events in a year 7-10 event years in 10	Winter Spring	• Native vegetation	• 2 • 6	• Increase the extent and diversity of flood dependent vegetation communities • Provide habitat for wetland specialist fish • Exchange of food and organic material between the floodplain and channel • Increase breeding and feeding opportunities for native fish, waterbirds and amphibians	2011
4	Overbank*	40 000	4+ day 1 – 2 events in a year 4 - 6 event years in 10	Winter Spring	• Native vegetation	• 2 • 6	• Increase the extent and diversity of flood dependent vegetation communities higher on the floodplain • Provide habitat for wetland specialist fish • Exchange of food and organic material between the floodplain and channel • Increase breeding and feeding opportunities for native fish, waterbirds and amphibians	2011
4	Rate of flow rise	Max rate of 0.38/0.38/1.20/0.80 metres river height in summer/autumn/ winter/spring		All year	• Native fish • Macroinvertebrate	• 1 • 3	• Reduce displacement of macroinvertebrates and small/juvenile fish	2007
4	Rate of flow fall	Max rate of 0.15/0.15/0.78/0.72 metres river height in summer/autumn/ winter/spring		All year	• Geomorphology • Native fish • Macroinvertebrate	• 1 • 3 • 4 • 5	• Reduce bank slumping/erosion and stranding of macroinvertebrates and small/juvenile fish	2007

*Proposed flows only, cannot currently deliver

Appendix 6: Risk Assessment Methodology

A high level assessment of the potential adverse environmental outcomes was completed in line with the requirements of AS/NZS ISO 31000:2009 (Tranter, 2015). The assessment considered the potential environmental risks in the Goulburn River below Lake Eildon, as well as the receiving River Murray (Tranter, 2015).

The risk assessment considered the likelihood of a negative environmental response occurring and the severity of the outcome if that event occurred. The assessment generated a risk matrix in line with the ISO standards and evaluated the availability and effectiveness of management options to diminish those risks (mitigation options).

Table A-112: Risk assessment matrices

Risk Ranking		Consequence				
		Insignificant	**Minor**	**Moderate**	**Major**	**Extreme**
Likelihood	**Rare**	Low	Low	Low	Low	Moderate
	Unlikely	Low	Low	Low	Moderate	Significant
	Possible	Low	Low	Moderate	Significant	High
	Likely	Low	Moderate	Significant	High	High
	Almost certain	Moderate	Significant	High	High	Intolerable

The broad approach to completing the risk assessment involved the following steps:

1. Developing a risk register drawing on experience of delivering similar projects that considers potential environmental risks for the **project development** and **operational** phases of the project
2. Using the risk register to identify categories of threat, individual threats and a risk rating for each threat with a score against:
   - The likelihood of those events occurring
   - The consequence of the outcome if the event occurred
   - A (pre-treatment) risk rating based on the combination of likelihood and consequence
   - The available mitigation strategies and controls to offset these risks
   - The residual risk once those controls were imposed.

The risk register was developed by a team of specialists with knowledge of the relevant sites and experience of delivering similar projects. This risk register identified core values at the sites, categories of threat, individual threats and a risk rating for each threat. The assessment also identifies the potential mitigation strategies and the level of residual risk once these have been implemented.

The draft risk assessment was presented to a workshop of key agency stakeholders in order to review and confirm the identified risks and the appropriateness of the proposed control activities, as well as any further work that needs to occur to better understand and/or manage the high priority risks.

The stakeholder agencies represented at the workshop included GBCMA, GMW, DELWP, Parks Victoria and the Murray-Darling Basin Authority (MDBA). This harnessing of local knowledge with broader stakeholder experience was effective in the identification of relevant threats and the informed allocation of likelihood and consequence ratings for each threat.

The outcomes of the risk assessment provides a preliminary basis for prioritising mitigation strategies and measures based on currently available information. A more detailed risk assessment would be carried out should the Basin Ministers decide to proceed further with the project.

Appendix 7: Significant pre-treatment risks identified through the assessment process

Threat	Description	Pre-treatment risk assessment			Mitigation options	Residual risk assessment (post-treatment)		
		Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
CONSTRUCTION PHASE								
ENVIRONMENTAL IMPACTS								
Loss of native vegetation	Modification or construction of new levees may require the removal of native vegetation in the construction footprint (both on the levees and growing adjacent to them) causing a loss of habitat and reduced population abundance of native vegetation communities in the local area.	5	7	7	Surveys conducted to allow detailed designs to minimise/avoid vegetation impacts. Include vegetation management in the construction Environmental Management Plan and follow legislative requirements as appropriate (including consideration of offsets). Ensure adequate supervision during construction phase.	3	2	5
Fire caused by construction equipment	Construction machinery or equipment may start a fire, causing loss of biodiversity (and potentially human and property damage).	3	5	8	Fire management plan developed. Site Environment Management Plan. Site safety plans. Liaison with fire services.	1	4	5
THIRD PARTY IMPACTS								
Damage to cultural heritage sites	Construction activities may damage identified sites as well as unidentified sites (discovered during construction) and may lead to delays, loss of goodwill and possible legal action/financial penalties.	3	4	7	Undertake thorough cultural heritage survey and investigation, project plan includes control and mitigation measures. Ensure adequate supervision and induction of contractors.	2	4	6

Threat	Description	Pre-treatment risk assessment			Mitigation options	Residual risk assessment (post-treatment)		
		Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Vehicle accidents	Accidents involving construction vehicles as well as public vehicles leading to project delays, possible legal action/financial penalties and most importantly, loss of life or serious injury.	2	5	7	Site Safety Plan to include risk assessment and mitigation measures to avoid vehicle accidents (e.g. speed limits, restricted access during wet weather, dust suppression, road condition inspections and repairs, road barriers to construction sites).	1	5	6
On-site injury to workers or community	Injuries to site workers during construction or members of the public at the work site including unauthorised visits leading to project delays, possible legal action/financial penalties and most importantly, loss of life or serious injury.	3	5	8	Site Safety Plan to include risk assessment and mitigation measures to identify and avoid site accidents (e.g. manual lifting, machinery operation, site safety briefings and barriers). Selection of contractors.	1	5	6
PROJECT DELIVERY RISKS								
Loss of support from funding agencies	Loss of support for the project from funding agencies could lead to possible cancellation of the project.	2	5	7	Funding agencies strongly involved in project implementation. Communication plan to include stakeholder consultation and briefings to identify and address any issues.	1	5	6
Lack of support - directly affected stakeholders	Landholders or agencies who are directly affected by the works may object leading to loss of goodwill, project delays, possible legal action and additional costs.	4	3	7	Communication plan to include landholder consultation and briefings to fully inform stakeholders, identify and address any issues.	4	3	7
Lack of political support	Lack of support at local, state and/or federal level could lead to project delays, negative publicity and potential stop work.	4	4	8	Communication plan to include political consultation and briefings to inform about the project and appropriately deal with stakeholder issues.	3	4	7
Insufficient budget for implementation	Approved funding is less than the estimated project cost meaning that the project cannot be completed unless additional funding is provided or the scope of works reduced.	3	4	7	Include suitable contingency allowances in cost estimate. Determine the impacts on project scope/outcomes of any shortfall in funding and communicate with funders to agree on a revised scope or additional funding.	3	2	5

Threat	Description	Pre-treatment risk assessment			Mitigation options	Residual risk assessment (post-treatment)		
		Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Inaccurate cost estimate	Project cannot be completed within the approved budget unless additional funding is provided or the scope of works reduced.	3	4	7	Probability based cost estimate (P50 and P90) to be prepared by a suitably experienced person based on design quantities, unit rates from previous relevant projects, and input from suppliers and contractors as required. Allow for expert peer review, contingency and cost escalations.	2	2	4
Unsuitable contractor	Contractor does not have the necessary experience, plant, financial resources and management systems and skills (safety, work scheduling etc.) to successfully complete the works resulting in delays, cost overruns and possible legal action.	3	4	7	Procurement strategy to include preparation of suitable tender documents and works schedules including contractor resources, experience and referees, and tender interviews undertaken by persons with experience in similar projects, contractor resources.	2	3	5
Uncertainty regarding future ownership	Disagreement between agencies regarding future responsibility for the operation and maintenance of the works leading to a deterioration of the works, driven by levees.	3	4	7	Attempt to obtain legal agreements that clearly define the roles and responsibilities of all parties before the project is approved. Operator input to design and construction process.	2	2	4
Bushfire	Bushfire impacts on construction activity leading to possible damage to persons (including fatality) and property, loss of goodwill, damage costs and project delays.	3	5	8	Liaison with fire services to ensure that bushfire warnings and information is communicated to construction crews. Usual fire controls in place in accordance with a Fire Management Plan.	3	2	5
Interruption to irrigation supply	Inconvenience and loss of production to landholders leading to loss of goodwill, additional costs, project delays and possible legal action.	4	3	7	Communication plan to include landholder consultation and briefings to identify and address any issues. Scheduling of works around irrigation season.	1	1	2

Threat	Description	Pre-treatment risk assessment			Mitigation options	Residual risk assessment (post-treatment)		
		Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Legal rights to access land	Commence negotiations before the project is approved. Land valuations conducted so that payment offered is considered reasonable. Ongoing engagement with directly affected landholders.	5	4	9	Commence negotiations before the project is approved. Land valuations conducted so that payment offered is considered reasonable. Ongoing engagement dealing with issues raised by directly affected landholders.	4	4	8
Change of staff	Loss of continuity resulting in poor communication, time delays, cost increases and loss of trust and corporate knowledge.	4	3	7	Identify backup staff for key roles (e.g. project manager, superintendent, works supervisor), ensure depth of project team and alternative employment models/succession plan.	3	2	5
OPERATIONAL PHASE								
ENVIRONMENTAL IMPACTS								
Loss of structural diversity in wetlands	Changes flow patterns may create conditions suitable for mass river red gum recruitment and establishment in wetlands and flood-runners, or encroachment of emergent macrophyte stands e.g. cumbungi, resulting loss of plant diversity and permanent changes to structural composition that negatively affect habitat for native fauna.	4	3	7	Implement the Environmental Water Management Plan taking (EWMP) into account the ecological objectives. Adaptively manage in response to monitoring and evaluation outcomes and update the EWMP as required. Implement river red gum thinning programs as required.	3	2	5
River capture	The passage of water through quarries located on the floodplain near to the river may cause an avulsion that leads to a change in channel course resulting in damage to commercial activities and reputational risks.	3	5	8	Ensure at risk sites are identified during project development and appropriate measures e.g. levees are implemented to manage the risk. Residual risk not scored as further investigation is needed into options that mitigate this risk.	1	5	6

Threat	Description	Pre-treatment risk assessment			Mitigation options	Residual risk assessment (post-treatment)		
		Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
River avulsion	High river flows may cause avulsion in the main river channel leading to increased sedimentation that smothers the stream bed reputational damage and potential flooding of private land (attributed to operations whether caused by it or not).	3	5	8	Ensure at risk sites are identified during project development and appropriate measures e.g. waterway management works i.e. stock exclusion and vegetation management.	1	5	6
Increased rates of erosion and bank slumping	High river flows may result in erosion of river banks and/or slumping during periods of flow recession leading to a loss of streambank vegetation and habitat e.g. mature river red gum trees reducing the diversity and extent of native flora and fauna, as well as destabilising water extraction sites and possible loss of farmland.	4	3	7	Incorporate and refine allowable rates of rise and fall into the Operating Strategy. Seek funding to continue the implementation of the Goulburn River Large Scale Restoration project and implement erosion control activities as required.	3	2	5
Increased populations of exotic fish species	Inundation of the floodplain may create favourable breeding conditions for exotic fish e.g. European carp leading to increased populations on the floodplain and dispersal during subsequent periods of connectivity impacting on aquatic vegetation and competition for resources with native fish populations.	5	2	7	Implement the Environmental Water Management Plan (EWMP) taking into account the ecological objectives. Adaptively manage in response to monitoring and evaluation outcomes and update the EWMP as required. Undertake event-based monitoring to better understand management options for minimising exotic fish species responses.	5	2	7
THIRD PARTY IMPACTS								
Underestimated flood extent	Errors in flood estimates result in unexpected areas of flooding leading to compensation claims, legal action and loss of goodwill - finance and reputation - driven by potential spatial or financial inaccuracy.	4	4	8	Measure inundation in actual flow events and further refine the hydraulic model. Phased implementation of the operating plan.	2	4	6

Threat	Description	Pre-treatment risk assessment			Mitigation options	Residual risk assessment (post-treatment)		
		Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Damage to roads on floodplain	Damage to roads (public and private) on floodplains could lead to increased vehicle accidents leading to compensation claims, legal action and loss of goodwill. Increased frequency of flooding (in the operational phase) may lead to increased maintenance costs for Parks Victoria or local government.	2	5	7	Ensure ongoing maintenance and repair funding and responsibilities have been agreed The proposed package of works to include upgrade of roads and bridge structures to ensure that safety issues are considered. Install warning signs as/where appropriate. Communications during seasonal planning.	1	5	6
OPERATIONAL IMPACTS								
OH&S risks to operational staff	Operation of regulating structures on floodplains poses a range of potential OH&S risks - driving to access sites, risk of injury when accessing and operating structures (incl. snakebite), working over water.	3	5	8	Mitigation options should follow the hierarchy of controls - design of works needs to focus on reducing risks through: - safe design, to reduce risk of injury - incorporation of remote operational capabilities where warranted. Safe working practices and strong safety management would also mitigate risks.	1	5	6
Structural failure of levees during managed or natural events	Levees may fail allowing water to flow onto public and private land causing damage resulting in compensation claims.	3	4	7	For new or upgraded levees, attention to design of levees and appropriate soil testing and construction supervision as identified in construction phase risk mitigations. Effective asset management program to be established for O&M phase, with condition assessment and programmed maintenance.	1	4	5

Threat	Description	Pre-treatment risk assessment			Mitigation options	Residual risk assessment (post-treatment)		
		Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Structural failure of levees during natural events that overtop levees i.e. flows greater than 55,000 ML/d	Levees may fail allowing water to flow onto public and private land causing damage resulting in compensation claims.	5	4	9	Effective asset management program to be established for O&M phase, with condition assessment and programmed maintenance. This includes the timely repair of levees damaged by large natural flood events.	1	4	5
Failure of flow control structures within levees	Flow control structures within the levee may fail through a range of mechanisms including leakage around the structure, erosion downstream of the structure due to flow through the regulator or structural failure of the embankment or regulating doors.	3	4	7	Good practice design of structures and appropriate construction supervision as identified in construction phase risk mitigations. Effective asset management program to be established for O&M phase, with condition assessment and programmed maintenance as necessary.	1	4	5
Uncertainty in predicting tributary inflows	If tributary inflows are not able to be predicted with sufficient accuracy, actual e-flows achieved may be higher or lower than planned, resulting in unplanned inundation/levee overtopping or failure to achieve intended environmental outcomes.	4	5	9	Consideration of freeboard requirements on levees and agreements to assist in managing risk. Development of overall operational strategy and procedures to manage risks. Key elements likely to include review of flow monitoring and telemetry networks; adaptation of existing rainfall run-off modelling (e.g. BoM models) for operational use and/or utilising enhanced operational forecasting and analysis tools like eWater Source and FEWS; implement operational risk mitigations including managing levels in Waranga Basin to allow diversion of high flows at Goulburn Weir etc. Initial trials and phased implementation of watering program.	3	4	7

Threat	Description	Pre-treatment risk assessment			Mitigation options	Residual risk assessment (post-treatment)		
		Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Lack of operator experience	Inexperienced operators may not be able to predict inflows or co-ordinate travel times accurately enough to achieve intended flows. May result in unplanned inundation/levee overtopping or failure to achieve intended environmental outcomes, and/or loss of stakeholder confidence in ability to manage.	4	4	8	Development of overall operational strategy and procedures to manage risks. Implement operator training program including real time simulation exercises based on current overbank flow events. Capture operational decision-making and use adaptive management processes and decision support tools to build capability.	2	4	6
Rights to access land do not reflect operations	Agreements (compensation calculations) are based on a planned frequency, duration and extent of flooding. This may limit future operations if the appropriate flood frequency and duration is not used in the calculations.	3	5	8	Measure river heights during actual flow events and update hydraulic models to ensure agreements cover actual areas subject to inundation based on future operational needs. Consult and inform potentially affected landholders.	2	4	6
Increased flood risks when natural floods follow a high flow release	Rainfall events in the catchment below Lake Eildon may generate local inflows after water has been released from Eildon and is already in transit, resulting in increased flooding and potential damages.	4	4	8	Development of overall operational strategy and procedures to manage risks. Key elements likely to include review of flow monitoring and telemetry networks; adaptation of existing rainfall run-off modelling (e.g. BoM models) for operational use and/or utilising enhanced operational forecasting and analysis tools like eWater Source and FEWS, in conjunction with scenario testing using BoM 7 day rainfall forecasts; implement operational risk mitigations including managing levels in Waranga Basin to allow diversion of high flows at Goulburn Weir and adequate buffers.	3	4	7
Lack of funding for operation, maintenance and renewal costs	Ongoing operation and maintenance activities cannot be fully implemented leading to deterioration of the works and perceived underperformance of the project.	3	4	7	Obtain ongoing funding commitments to cover future O&M activities at project development e.g. through establishment of water management scheme.	2	2	4

Threat	Description	Pre-treatment risk assessment			Mitigation options	Residual risk assessment (post-treatment)		
		Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Operational clashes with other downstream activities	Release of e-flows in the Goulburn River may reach the River Murray when high flows are occurring due to natural processes or e-flow releases, causing increased flooding and damage.	4	4	8	Integrated planning of basin wide e-water delivery actions, through SCBEWC and OAG processes. Co-ordination and liaison between GMW and MDBA RMO to ensure impacts of planned operations are assessed and managed.	1	2	3
Lack of monitoring funding	Failure to adequately monitor the ecological outcomes of the project activities restricts the ability to demonstrate the full benefits of the works leading to perceived underperformance/failure of the project, loss of stakeholder support, failure to endorse watering plans and limited opportunities for adaptive management.	3	4	7	GBCMA to seek adequate sources of funding (e.g. through CEWH and potential research partnerships with other organisations such as universities, ARI, ECL).	2	2	4
Lack of understanding regarding roles and responsibilities	Disagreement and confusion between agencies leading to a failure to fully implement monitoring, operation and maintenance activities and a consequent deterioration of the works.	3	4	7	Clearly define the roles and responsibilities of all parties and formalise the roles before the project is implemented.	2	2	4
Lack of certainty regarding liability	Uncertainty amongst agencies regarding risk and indemnity issues, as well as different risk appetites, may lead to concerns over liability (financial) impacts and result in lack of endorsement for seasonal watering projects or planned water activities not being fully implemented.	4	4	8	Clearly define the roles and responsibilities of all parties and formalise the roles before the project is implemented.	3	4	7

Threat	Description	Pre-treatment risk assessment			Mitigation options	Residual risk assessment (post-treatment)		
		Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Change to private land ownership	Change in responsibility for the satisfactory performance of the work leading to gradual deterioration of the works.	3	4	7	Obtain legal agreements that clearly define the roles and responsibilities of all parties before the project is approved. Agreements to be registered on title to ensure they are not affected by a change in land ownership.	2	2	4
Environmental water requirements underestimated	Works do not perform as expected (e.g. uncertainty regarding estimating losses) and the expected benefits are not achieved.	3	4	7	Sanity check and expert peer review of planned operating strategies. Phased implementation and ground-truthing of the operating plan. Reallocate additional water from environmental water holding.	2	2	4

Appendix 8: January 2016 Community Open House Sessions

Introduction

On behalf of the Victorian Government, the Goulburn Broken Catchment Management Authority with the support of the Murray-Darling Basin Authority developed the Goulburn River Constraints Management Business Case between May 2015 and February 2016. The business case assessed the feasibility of adding reservoir releases to natural flow events in the Goulburn River to increase the frequency of low level flooding along the lower Goulburn River floodplain to improve the health of riverine ecological values. The business case also assessed the public and private impacts of the increased flows and the cost to government to mitigate or offset these impacts.

Consistent with the communications and engagement plan developed for the Goulburn River Constraints Management Business Case, public meetings (open house sessions) were held in August 2015 to inform and seek feedback from the local community on the rationale and aims of the project.

In January 2016, a second series of 18 open house sessions were held to discuss and seek feedback from the local community on the target flow rates identified in the final business case and the costs to mitigate or offset potential impacts. Overall, 246 people attended the sessions (approximately 25% more people than the August 2015 sessions) with some people attending more than one session. The location, date and time of each sessions is outlined in the table below along with the total number of attendees.

Location	Date	No. of sessions	Time of sessions	Total no. of attendees
Murchison	Friday 15th January 2016	1	2.00 pm 3.00 pm	12 2
Yea	Saturday 16th January 2016	2	11.00 am 2.00 pm	25 7
Molesworth	Monday 18th January 2016	3	12.00 pm 3.00 pm 6.00 pm	21 10 8
Alexandra	Tuesday 19th January 2016	3	12.00 pm 3.00 pm 6.00 pm	22 8 3
Shepparton	Wednesday 20th January 2016	2	12.00 pm 3.00 pm	11 13
Undera	Wednesday 20th January 2016	1	7.00 pm	19
Bunbartha	Thursday 21 January 2016	2	12.00 pm 3.00 pm	19 9
Kotupna	Thursday 21 January 2016	1	7.00 pm	29
Seymour	Friday 22nd January 2016	2	12.00 pm 3.00 pm	23 5

People were advised of the open house sessions via: a direct mail out to landowners along the Goulburn River and along various tributaries (over 1200 letters sent); an email was sent to people who were involved in the project or attended the August 2015 open house sessions; advertisements placed in local newspapers; and word of mouth.

This document summarises the key points raised at open house sessions and the results of the feedback forms.

Key points raised at open house sessions

The following is a summary of the key points raised at the sessions grouped by theme. The points are not direct community quotes but summaries made by agency staff who attended or ran the sessions.

Target flow rates

- The community is relieved the 40,000 ML/day target flow rate in the lower Goulburn and the 20,000 ML/day flow target in the mid-Goulburn are no longer being considered in the business case. However, significant concern about the risk of delivering the revised lower flow targets still remains (how securely events can be managed within the proposed buffer levels).

- Impacts are still felt to be significant and disruptive for Molesworth landholders, mainly at the buffer level (and whether it is adequate), but also at the target flow rate of 10,000 ML/day at Alexandra. This is partially due to uncertainty as to what a 10,000 ML/day flow at Alexandra could turn into by the time it moves downstream to Molesworth.
- The duration of flow events have not been defined tightly enough, especially as it is a major driver of the amount of damage that is done.
- There needs to be safeguards (checks and measures) to ensure decision makers do not increase target flow rates in the future and decrease the protection provided by the buffer levels.

Flow footprint mapping

- The community is concerned the flow footprint mapping in the Molesworth region is not accurate and therefore the number of properties and the size of area affected by the target flow rates and the buffer levels are considered underestimated.

Mitigation and offset costs

- There is a lot of confusion about how you can calculate an upfront cost large enough to pay for a recurrent flood event in perpetuity. Many landholders suggested an event based compensation process would be preferred.
- There was concern the costing assumptions used to determine agricultural land worth and clean-up costs after a flow event were inaccurate or inappropriate.
- The community expressed the need for independent legal and farm advice for affected landholders not just advice at a community reference group level as currently costed in the business case.
- Does the compensation for the decreased production value of the land actually compensate for the decrease in market value (i.e. whether or not more flooding does affect other 'lifestyle' components of market value, not just production value)?
- How is the future potential of the land taken into account, not just its current use?
- How is the contribution of the affected land to the whole farm enterprise costed? The impacted land could be integral to the functioning and feasibility of a farm (primary source of water, stock feed, shelter).
- The following costs have not been detailed in the business case:
    - Impacts on Goulburn River landholders from flow interactions with the Murray River.
    - Impacts on tributary landholders (e.g. Broken Creek and Seven Creeks) from flow interactions with the Goulburn River (also see comment under Other heading below).
    - Councils who want some of their public infrastructure assets to be upgraded to maintain access rather than the current costing assumption of reinstatement.
    - If property values decrease it could decrease the rate income to councils.
    - Flow on effects to the economy and community (other businesses in the region) from reduced tourism because of increased flooding.
    - Contribution to Loch Garry operation and maintenance as constraints flows are relying on the structure to be in place and remain in good condition.
    - River bank erosion and avulsion control as a consequence of increased flooding.

Easements

- How would easement acquisitions be negotiated?
- Local community reference groups should provide input into the design and implementation of the easement acquisition process.
- Vulnerable landholders (e.g. the elderly and people with mental health issues) should be considered in the design and implementation of the easement acquisition process.
- There was concern easement acquisitions would not stay voluntary and would become compulsory.
- Affected landholders should be provided with access to independent farm and legal advice at an individual property level.

Other

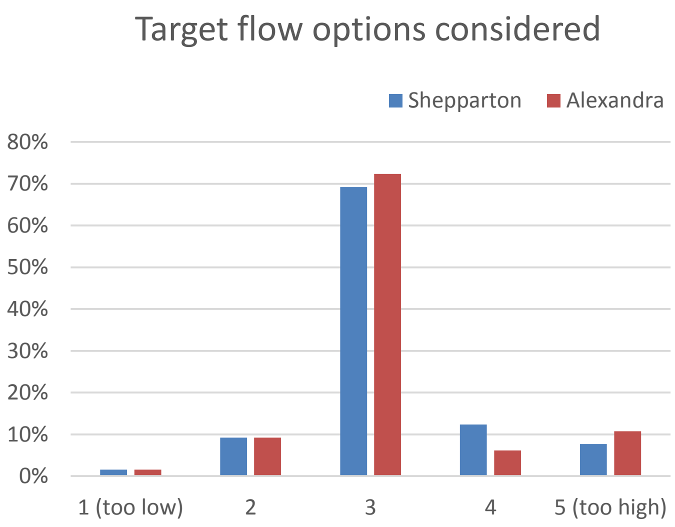
- Exacerbated flood risk (risk of making a follow up flood worse) continues as a key community issue all along the Goulburn River. This relates to uncertainty around how tightly flows can be managed during an event, whether the buffers are of sufficient size, and for the lower Goulburn how much the filling up of the floodplain storage (wetlands) could affect the severity of a follow up flood.
- People in the mid-Goulburn were unhappy that tributary impacts were only recognised as needing further work and were not included in any cost estimates in the business case (as work this year showed limited impact on backing up and tributary time to drain which doesn't match with landholder views).
- Unhappy that governments are making decisions without all the information being in place.
- The assumption of predominantly public infrastructure reinstatement rather than upgrade is considered risky by some councillors. View was put that where properties and business could be isolated for seven days or more, infrastructure should be upgraded.
- The development of a real time river level monitoring phone app with advance notification capability would assist affected landholders and communities.

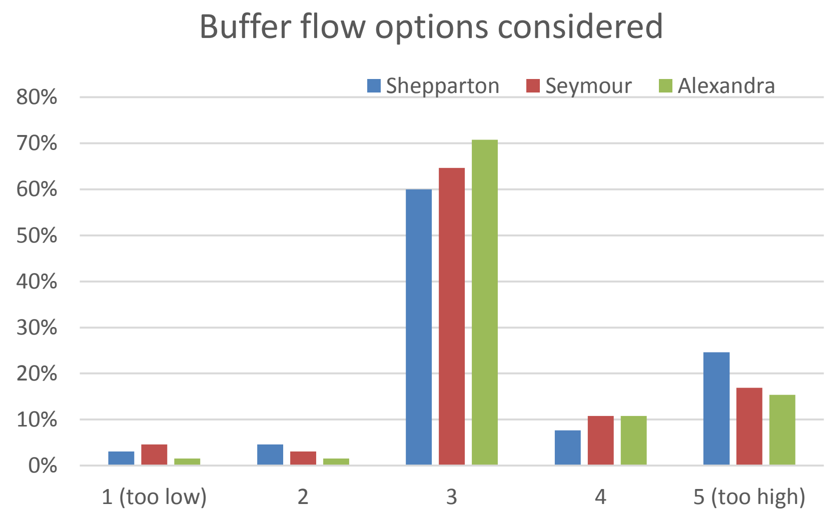
Feedback sheets

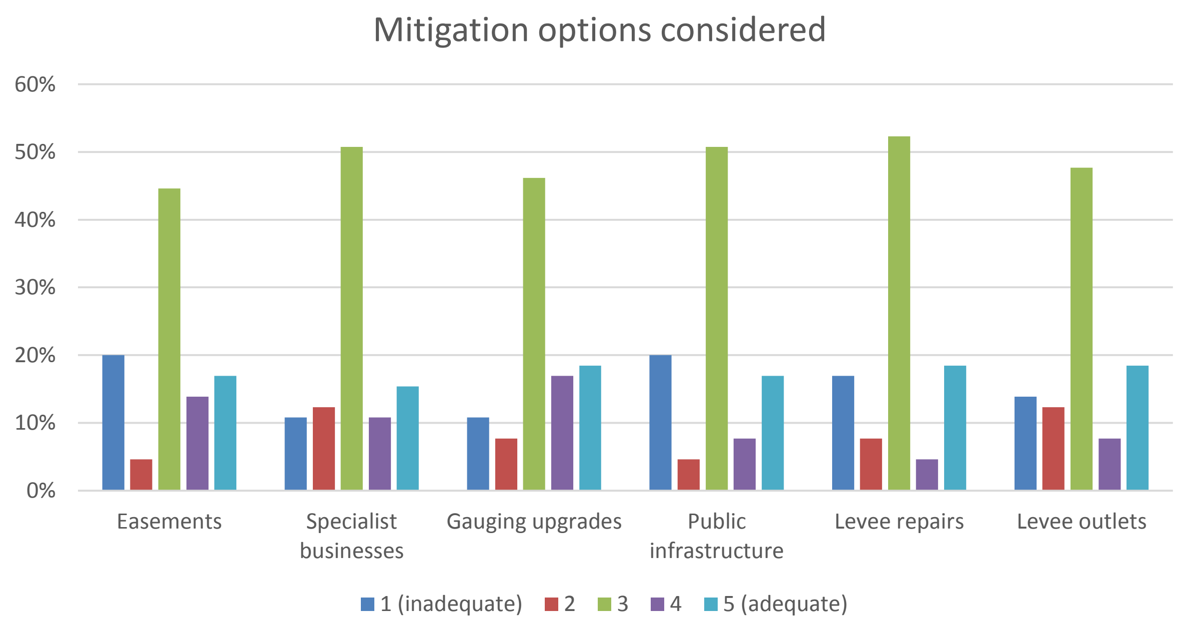
Feedback sheets were made available to session attendees. A total of 57 completed feedback sheets have been received by the GBCMA to date. The feedback sheets asked the following seven questions:

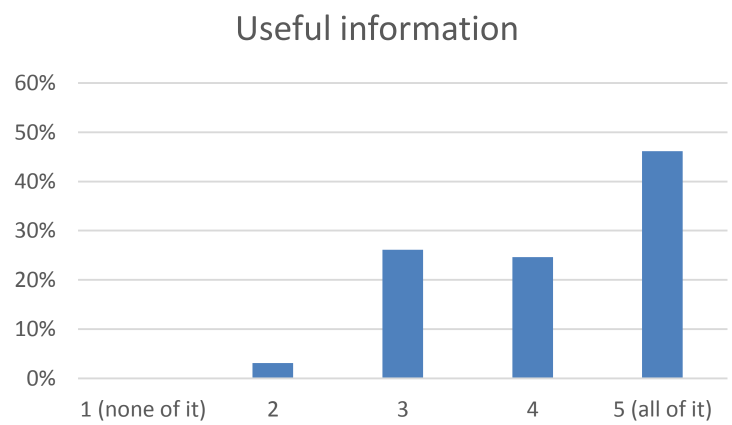
- How did you hear about the event?
- What do you think about the target flow options being considered?
- What do you think about the buffer flow options being considered?
- What do you think about the package of mitigation options being considered?
- Please rate the information provided?
- How satisfied were you with opportunities to ask questions and the answers to your questions?
- Do you have any other comments or feedback?

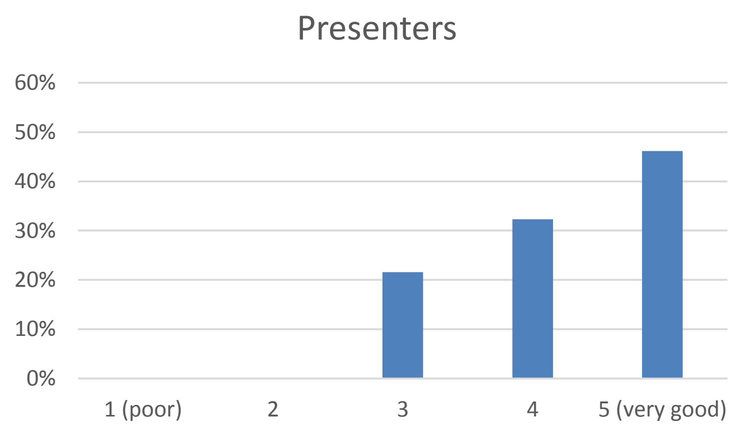
The questions were a combination of multiple choice and free text. A summary of the multiple choice answers received are provided in the graphs below.

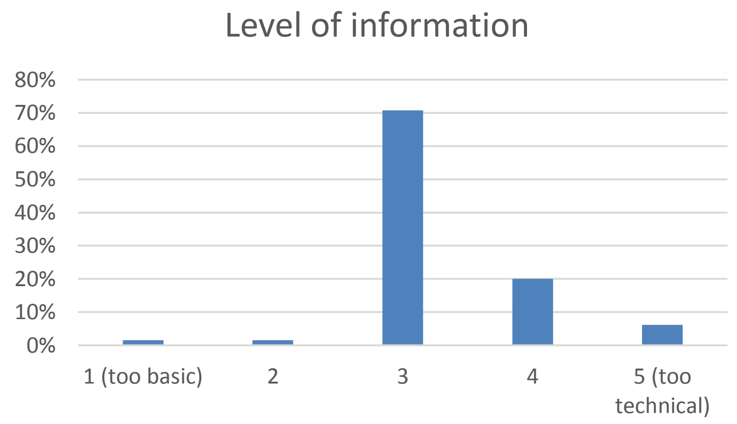


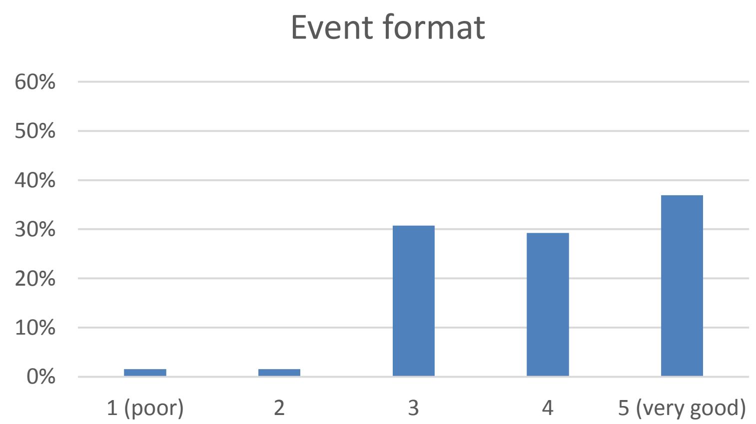

Buffer flow options considered
Shepparton
Seymour
Alexandra
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 (too low)
2
3
4
5 (too high)


Mitigation options considered
60%
50%
40%
30%
20%
10%
0%
Easements
Specialist businesses
Gauging upgrades
Public infrastructure
Levee repairs
Levee outlets
1 (inadequate)
2
3
4
5 (adequate)


Useful information
60%
50%
40%
30%
20%
10%
0%
1 (none of it)
2
3
4
5 (all of it)


Presenters
60%
50%
40%
30%
20%
10%
0%
1 (poor)
2
3
4
5 (very good)


Level of information
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 (too basic)
2
3
4
5 (too technical)


Event format
60%
50%
40%
30%
20%
10%
0%
1 (poor)
2
3
4
5 (very good)