Amendment date: 28 June 2017

	Title of measure	**Guttrum and Benwell Forests Environmental Works Project**
	Proponent undertaking the measure	**Victoria**
	Type of measure	**Supply**
1.	**Confirmation**	
	Date by which the measure entered into or will enter into operation *Must be before 30 June 2024*	This environmental works project will be operational by 30 June 2024.
	Confirmation that the measure is not an 'anticipated measure' *'Anticipated measure' is defined in section 7.02 of the Basin Plan to mean 'a measure that is part of the benchmark conditions of development'.*	Yes.
	Confirmation that the proponent state(s) undertaking the measure agree(s) with the notification ***Basin Plan 7.12(3)(c)*** *Joint proposals will need the agreement of all proponents*	Yes.
2.	**Details of the measure**	
	Capacity of the measure to operate as a supply measure *'Supply measure' is defined in section 7.03 of the Basin Plan to mean 'a measure that operates to increase the quantity of water available to be taken in a set of surface water SDL resource units compared with the quantity available under the benchmark conditions of development'.*	Yes.
3.	**Description of the works or measure**	
	The project will reinstate a more natural flooding regime for the Guttrum and Benwell Forests, addressing, in particular, the reduced frequency and duration of floods. The proposed works will water 1,200 ha via the irrigation channel system, including semi-permanent wetlands and 82% of the river red gum forest with flood dependent understorey. The works will include two separate channels to deliver environmental water into Guttrum Forest, one channel in Benwell Forest and containment works (regulators and levees) in both forests to contain water on the floodplain. The works have been designed to meet the environmental watering requirements of the ecological values by mimicking a 26,000 ML/d flood event in the River Murray for Guttrum Forest and a 24,000 ML/d flood event for Benwell Forest. A detailed description of the proposed works package is included in Chapter 2.3 and 11 of the business case **(Attachment B)**.	
4.	**Geographical location of the measure**	
	Guttrum and Benwell Forests are located on the mid-Murray floodplain of northern Victoria, downstream of Koondrook and have a combined area of 1,930 hectares.	
5.	**Representation of the project in the MDBA modelling framework**	
	The MDBA has represented the proposed infrastructure, operating strategies and water use in the MSM-BigMod model. Data used by the MDBA was sourced from the DHI operational water scenario modelling report which was supplied as a supporting document to the business case. A schematic of the new representation of the floodplain is included in **Attachment A**. Spatial data provided by the proponent (derived using a hydro-dynamic model) describes the areas inundated through the operating of the works. The areas inundated are combined with the timing of modelled operation by the Environmental Outcomes Scoring Tool to quantify the change in environmental outcomes, relative to the Benchmark environmental outcomes.	

To enable the storage sites to be represented in MSM-Bigmod the following relationships have been incorporated. These relationships are based on the report supplied by DHI as extracted from topographic dataset within the forest boundary levees.

Guttrum Forest Sill = 74.2 mAHD				Benwell Forest Sill = 73.8 mADH			
Level (mAHD)	Volume (ML)	Area (ha)	Inlet Capacity	Level (mAHD)	Volume (ML)	Area (ha)	Inlet Capacity
74.0	0	0	0	73.6	0	0	0
74.4	14	2	15	73.8	3	2	50
74.6	20	4	20	74.0	23	18	80
74.8	52	28	50	74.2	112	72	100
75.0	175	95	80	74.4	374	191	150
75.2	447	176	150	74.6	885	320	250
75.4	894	271	400	74.8	1634	429	1200
75.6	1410	445	600	75.0	2562	500	1500
75.8	2737	681	750	75.2	3599	537	1800
76.0	4307	889	800	75.4	4701	565	2000
76.2	6227	1031	900				
76.4	8364	1106	1000				
76.6	10519	1149	1000				
80.0	11519	1249	1000				

Interaction between river flows and site inflow

The sites are modelled as two lakes (Guttrum and Benwell forest) as off-channel storages from the River Murray. For a lake storage both the inflow and return flow are governed by the level difference at the point of connection to the river and the inlet capacity as in the table above, using the following relationship:

$$Q = C\sqrt{\Delta h}$$

Where, Q = flow, Δh = level difference between offtake point and lake, and C = inlet capacity

While water level in the lakes is calculated from the relationship described the table above, river level at offtake point is obtained from the relationship of river flow and level the table below. Both tables are drawn by the MDBA based on hydrodynamic model results developed by DHI

D/S of Guttrum Forest		D/S of Benwell Forest	
Flow (ML/d)	Level (mAHD)	Flow (ML/d)	Level (mAHD)
0	67.48	0	69.28
5000	72.05	3460	70.54
7700	73.56	9500	73.20
8850	73.97	10000	73.50
10100	74.28	13000	73.97
12000	74.52	15130	74.26
14000	74.88	16430	74.42
15000	75.01	19000	74.74
17000	75.29	21000	74.93
20000	75.60	25000	75.10
25000	75.85	30000	75.30
30000	76.40		

Surface water loss relationships

The hydrodynamic model has applied historical daily evaporation rates corrected by pan factor observed from the Kerang station. A seepage loss rate of 2mm/d is modelled in 2D modelling. In MSM-Bigmod a standard loss rate for evaporation is applied based on monthly data from climate station at Swanhill. A constant seepage loss rate of 2 mm/day has been applied for the site

6. **Representation of each operating strategy in the MDBA modelling framework.**

Chapter 9 of the Business Case (**Attachment B**) outlines a series of proposed operating regimes. This information has been summarised and outlined below

Operating Strategy	Frequency	Equivalent River Flow and water regime	Target	Operation
Guttrum Forest River red Gum watering	3 in 10 years	24,000 ML/d at Barham	Desired inundation extent 727 ha at 75.8 mAHD during Winter/Spring	Filling at peak flow of 250 ML/d for 33 days, outlet structure closed. Then maintenance flow of 50 ML/d for 110 days with outlet structure open.
Guttrum Forest Semi permanent wetland watering	7 in 10 years	23,000 ML/d at Barham	Desired inundation extent 267 ha at 75.5 mAHD during Winter/Spring.	70 ML/d for 9 days, maintenance flow 15 ML/d for 65 days. No flow through outlet
Hybrid scenario of Guttrum Forest			To retain floodwater in the floodplain and provide top-up flows to extend the duration of natural flood	Outlet and low lying inlet regulators closed after the river flow peak has passed. Top-up with 250 ML/d
Benwell Forest River red Gum watering	3 in 10 years	24,000 ML/d at Barham	Desired inundation extent 481 ha at 75.0 mAHD during Winter/Spring.	Filling at peak flow of 250 ML/d for 15 days, outlet structure closed. Then maintenance flow of 50 ML/d for 110 days with outlet structure open
Benwell Forest Semi permanent wetland watering	7 in 10 years	18,000 ML/d at Barham	Desired inundation extent 60 ha during Winter/Spring	125 ML/d for 4 days; maintenance flow 20 ML/d for 65 days. No flow through outlet
Hybrid scenario of Benwell Forest			To retain floodwater in the floodplain and provide top-up flows to extend the duration of natural flood	Outlet and low lying inlet regulators closed after the river flow peak has passed. Top-up with 250 ML/d

The operating strategies are modelled as outlined below

Operating Strategy	Frequency	Duration	Target	Water used
Gulthrum Red Gum watering	1 in 2 years	2 months	Sill at 75.8 mAHD on the first month then fully opened	250 mL/d in the first month then replenishing flow of 50 ML/d
Gulthrum Wetland watering	Opportunistic after 2 years	2 months	Sill at 75.5 mAHD on the first month then fully opened	70 mL/d in the first month then replenishing flow of 15 ML/d
Benwell Red Gum watering	1 in 2 years	2 months	Sill at 75.0 mAHD on the first month then fully opened	250 mL/d in the first month then replenishing flow of 50 ML/d
Benwell Wetland watering	Opportunistic after 2 years	2 months	Sill at 74.4 mAHD on the first month then fully opened	125 mL/d in the first month then replenishing flow of 20 ML/d

Hybrid events: The Murray model automatically reduces environmental diversions to the sites when piggybacking natural events.

7. Spatial data describing the inundation extent associated with the operation of the measure

The area of inundation associated with the operation of the works has been modelled with the hydrodynamic model. The total area of inundation for each of the operating strategies is given in the table below.

Operation strategy	Inundation area (ha)
Gulthrum River Red Gum watering (GTR)	736
Gulthrum semi-permanent wetland watering (GTW)	517
Benwell River Red Gum watering (BNR)	494
Benwell semi-permanent wetland watering (BNW)	166

For the purpose of calculating *scaling factors* for the Ecological Outcomes scoring method, the maps of the inundation areas associated with the works were combined with maps of SFI flow bands and maps representing the ecological elements used in the scoring method. The areas for the resulting hydrological assessment units (HAU) are provided in tables below. The area inundated by the Red Gum watering strategies (GTR and BNR), includes the areas inundated by the respective Wetland watering strategies (GTW and BNW respectively). The tables for GTR and BNR below provide the areas inundated *in addition* to the area already inundated by the wetland strategy.

Inundation area (ha) for GTW	SFI Flow Bands				
Ecological Element	16,000	20,000	30,000	40,000	>40,000
General health and abundance – all Waterbirds	0.0	0.0	461.0	43.0	13.0
Bitterns, crakes and rails	0.0	0.0	460.5	42.9	12.9
Breeding – Colonial-nesting waterbirds	0.0	0.0	461.0	43.0	13.0
Breeding – other waterbirds	0.0	0.0	460.5	42.9	12.9
Redgum Forest	0.0	0.0	421.4	40.0	11.7
Redgum Woodlands	0.0	0.0	14.4	0.5	0.4
Forests and Woodlands: Black Box	0.0	0.0	13.2	1.4	0.7
Lignum (Shrublands)	0.0	0.0	0.0	0.0	0.0
Tall Grasslands, Sedgelands and Rushlands	0.0	0.0	460.5	42.9	12.9
Benthic Herblands	0.0	0.0	0.0	0.0	0.0
Short lived fish	0.0	0.0	460.5	42.9	12.9
Long lived fish	0.0	0.0	461.0	43.0	13.0

Inundation area (ha) for GTR	SFI Flow Bands				
Ecological Element	16,000	20,000	30,000	40,000	>40,000
General health and abundance – all Waterbirds	0.0	0.0	175.0	27.0	17.0
Bitterns, crakes and rails	0.0	0.0	175.0	26.7	16.7
Breeding – Colonial-nesting waterbirds	0.0	0.0	175.0	27.0	17.0
Breeding – other waterbirds	0.0	0.0	175.0	26.7	16.7
Redgum Forest	0.0	0.0	161.1	25.0	16.5
Redgum Woodlands	0.0	0.0	7.1	1.6	0.5
Forests and Woodlands: Black Box	0.0	0.0	3.4	0.2	0.3
Lignum (Shrublands)	0.0	0.0	0.0	0.0	0.0
Tall Grasslands, Sedgelands and Rushlands	0.0	0.0	175.0	26.7	16.7
Benthic Herblands	0.0	0.0	0.0	0.0	0.0
Short lived fish	0.0	0.0	175.0	26.7	16.7
Long lived fish	0.0	0.0	175.0	27.0	17.0

Inundation area (ha) for BNW	SFI Flow Bands				
Ecological Element	**16,000**	**20,000**	**30,000**	**40,000**	**>40,000**
General health and abundance – all Waterbirds	0.0	90.0	52.0	21.0	3.0
Bitterns, crakes and rails	0.1	90.0	52.0	20.7	2.6
Breeding – Colonial-nesting waterbirds	0.0	90.0	52.0	21.0	3.0
Breeding – other waterbirds	0.1	90.0	52.0	20.7	2.6
Redgum Forest	0.2	82.9	49.4	19.6	2.6
Redgum Woodlands	0.0	0.0	0.5	0.8	0.0
Forests and Woodlands: Black Box	0.0	4.6	1.6	0.1	0.0
Lignum (Shrublands)	0.0	0.0	0.0	0.0	0.0
Tall Grasslands, Sedgelands and Rushlands	0.1	90.0	52.0	20.7	2.6
Benthic Herblands	0.0	0.0	0.0	0.0	0.0
Short lived fish	0.1	90.0	52.0	20.7	2.6
Long lived fish	0.0	90.0	52.0	21.0	3.0

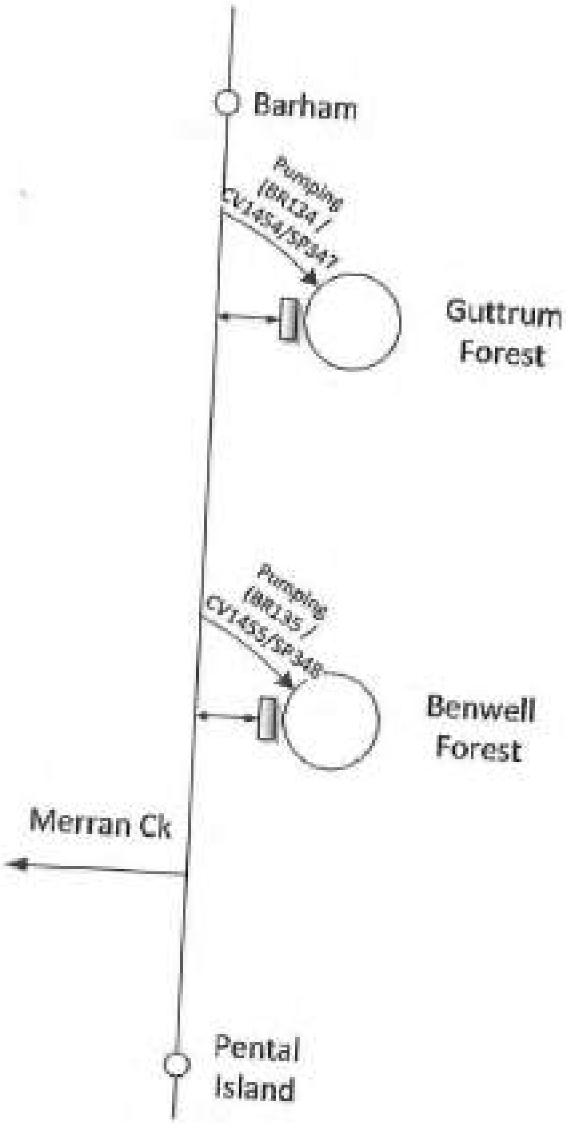
Inundation area (ha) for BNR	SFI Flow Bands				
Ecological Element	**16,000**	**20,000**	**30,000**	**40,000**	**>40,000**
General health and abundance – all Waterbirds	0.0	167.0	110.0	27.0	14.0
Bitterns, crakes and rails	0.0	166.6	109.1	25.7	11.4
Breeding – Colonial-nesting waterbirds	0.0	167.0	110.0	27.0	14.0
Breeding – other waterbirds	0.0	166.6	109.1	25.7	11.4
Redgum Forest	0.0	155.9	103.5	26.6	13.0
Redgum Woodlands	0.0	0.0	0.1	0.1	0.1
Forests and Woodlands: Black Box	0.0	5.8	3.8	0.2	0.2
Lignum (Shrublands)	0.0	0.0	0.0	0.0	0.0
Tall Grasslands, Sedgelands and Rushlands	0.0	166.6	109.1	25.7	11.4
Benthic Herblands	0.0	0.0	0.0	0.0	0.0
Short lived fish	0.0	166.6	109.1	25.7	11.4
Long lived fish	0.0	167.0	110.0	27.0	14.0

8.	**Surface water SDL resource units affected by the measure**
	This measure identifies all surface water resource units in the Southern Basin regions as affected units for the purposes of notifying supplying measures. The identification of affected units does not constitute an agreement between juristictions on apportioning the supply contribution, which will be required in coming months.
9.	***Details of relevant constraint measures***
	Not directly linked to any specific constraint measures but implementing a confirmed package of constraint measures may have implications for the proposed operating strategy.

Attachments:

A	MDBA	Guttrum Benwell floodplain enhancement project representation in Murray model
B	North Central CMA, December 2014	Phase 2 Assessment Supply Measure Business Case: Guttrum and Benwell Forests Environmental Works Project

Attachment A Guttrum Benwell floodplain enhancement project representation in Murray model (based on Bigmod Rev. 253)



Guttrum and Benwell Forests Environmental Works Project

SUSTAINABLE DIVERSION LIMIT ADJUSTMENT

Phase 2 Assessment

Supply Measure Business Case

2014

Victoria
Department of Environment and Primary Industries

NORTH CENTRAL Catchment Management Authority

Acknowledgement of Country

The North Central Catchment Management Authority acknowledges Aboriginal Traditional Owners within the region, their rich culture and spiritual connection to Country. We also recognise and acknowledge the contribution and interest of Aboriginal people and organisations in land and natural resource management.

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Foreword

Guttrum and Benwell Forests, situated on the River Murray floodplain downstream of Koondrook in northern Victoria, are River Red Gum floodplain forests of significant ecological importance in the Murray-Darling Basin. With a combined area of 1,930 hectares they comprise considerable areas of floodplain forest that support rare and threatened species, and stands of large old trees.

The *Guttrum and Benwell Forests Environmental Works Project* (the Project), described in detail in this document, is a proposed supply measure designed to off-set water recovery under the Murray-Darling Basin Plan by achieving equivalent or better environmental outcomes on the ground. The Project involves construction of works and minor channel works to reinstate the natural flooding regime. Delivered through low-complexity engineering the Project has excellent water saving and ecological credentials.

A feasibility study into the proposed project was approved on 11 December 2013 and developed into this detailed business case over a 12-month period. The Project is now sufficiently advanced that subject to funding, pre-construction approvals will occur in 2015, with construction commencing in 2016.

Current river operations have reduced the frequency of flooding from natural flooding eight years in 10 to four years in 10. Following extensive investigations to align ecology, hydrology and engineering, the Project will fill the current hydrological gap, via a package of works that will easily integrate with river and irrigation operations.

The core ecosystem communities of the forests that are influenced by the Project comprise semi-permanent wetlands; River Red Gum Forest; native fish and; native birds. A diverse range of waterbird and woodland species is known to make use of the forests, with at least 62 species of birds recorded, including important migratory birds covered by international agreements. The forests also provide critical floodplain forest habitat to mammals such as the recently recorded Yellow-footed Antechinus, and threatened amphibians such as the Growling Grass Frog.

The Guttrum and Benwell site is located in the heart of the Goulburn Murray Water managed Torrumbarry Irrigation Area. The local community has a strong understanding of the benefits of achieving water-efficient environmental outcomes through environmental watering infrastructure. Consultation through community events and one-on-one discussions has been positive with the local community, and landholders adjacent to the Project are supportive of the initiative.

The North Central CMA and its partners have established a strong track record in delivering environmental watering projects as demonstrated through the recent commissioning of large-scale infrastructure for watering the Gunbower Forest funded though The Living Murray program. This recent construction experience by the partners positions the region well to deliver on the stakeholder engagement, approvals, construction, commissioning and operation of the proposed new infrastructure.

On behalf of the North Central CMA and our project partners we commend this business case to you and emphasise that the region stands ready to proceed to the construction phase of the Project subject to funding.

David Clark
Chairman

Damian Wells
Chief Executive Officer

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Appendices

Abbreviations

AAV	Aboriginal Affairs Victoria
BOC	Basin Officials Committee
CAMBA	China Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
CMA	Catchment Management Authority
CMS	Constraints Management Strategy
CRG	Community Reference Group
Cwlth	Commonwealth
DBH	Diameter at Breast Height
Department	Commonwealth Department of the Environment
DEPI	Department of Environment and Primary Industries
EES	Environmental Effects Statement
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999
ESLT	Environmentally Sustainable Level of Take
ESLT report	*The proposed 'environmentally sustainable level of take' for surface water of the Murray–Darling Basin: Method and outcomes* (November 2011)
EVC	Ecological Vegetation Class
FDU	Flood-dependent Understorey
FFG Act	Flora and Fauna Guarantee Act 1988
FTU	Flood Tolerant Understorey
GIS	Geographic Information System
GMW	Goulburn-Murray Water
GST	Goods and Services Tax
Guidelines	Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases
ha	Hectare(s)
HIS	Hydrological Indicator Site
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)
JAMBA	Japan Australia Migratory Bird Agreement
km	Kilometre(s)
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MEP	Monitoring and Evaluation Plan
MERI	Monitoring Evaluation Reporting and Improvement
ML	Megalitres
mm/yr	Millimetres per year
OH&S	Occupational Health and Safety
PCB	Project Control Board
RAP	Registered Aboriginal Party
RiMFIM	River Murray Floodplain Inundation Model
RRG	River Red Gum

SCA	State Constructing Authority
SCADA	Supervisory Control and Data Acquisition
SDL	Sustainable Diversion Limits
SDLAAC	Sustainable Diversion Limit Adjustment Assessment Committee
SDLATWG	Sustainable Diversion Limit Adjustment Technical Working Group.
SDLLAC	Sustainable Diversion Limits Adjustments Assessment Committee
SFIs	Site-specific Flow Indicators
SPW	Semi- Permanent Wetland
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
WRC	Water Regime Class

Executive Summary

The *Guttrum and Benwell Forests Environmental Works Project* (the Project) is an environmental water infrastructure proposal that will contribute to achieving the 'Sustainable Diversion Limit (SDL) Off-set' element of the Murray Darling Basin Plan (Basin Plan). The Project is a 'supply measure', designed to off-set the Basin Plan's water recovery target of 2,750 gigalitres (GL) by achieving equivalent or better environmental outcomes on the ground. The Project is one of nine proposed infrastructure based supply measures being investigated within Victoria, and one of two within the North Central Catchment Management Authority (CMA) region.

The Guttrum and Benwell Forests business case (the Business Case) sets out the ecological objectives, proposed infrastructure package, operating strategies, ecological risks and benefits and the costs associated with the Project, from construction through to operation. It has been developed in partnership with the Department of Environment and Primary Industries (DEPI), Parks Victoria and Goulburn Murray Water (GMW). The following components provide an overview of the business case with the main conclusions summarised below.

Significance of the sites

Located on the mid-Murray floodplain of northern Victoria, Guttrum (1,270 hectares) and Benwell (660 hectares) Forests are two of the few remaining intact River Red Gum (*Eucalyptus camaldulensis*) floodplain systems in Victoria and are of significant ecological importance within the Murray-Darling Basin. The two adjacent forests form part of a wider regional ecosystem with Campbells Island directly opposite in New South Wales and the Gunbower-Koondrook-Perricoota Forest icon site immediately upstream.

River Red Gum floodplain forests provide essential habitat and resources for a diversity of native flora and fauna. European settlement and regulation of the River Murray has impacted significantly on these ecosystems, reducing their extent and changing flooding patterns. Remaining habitats are of high conservation value providing important refuges and hotspots for biodiversity. Guttrum and Benwell Forests are prime examples of this remnant floodplain forest ecosystem, supporting rare and threatened species, and stands of large old trees. A reduction in the frequency and duration of River Murray inflows however is impacting on their ability to support healthy floodplain communities.

Guttrum and Benwell Forests also provide a range of social and economic benefits including recreational activities, timber production and apiculture. The sites show evidence of both Aboriginal and European activities, and are particularly culturally significant for the Traditional Owners, the Barapa Barapa people.

Vision and objectives

The vision for Guttrum and Benwell Forests is to:

Maintain and restore healthy floodplain communities across Guttrum and Benwell Forests, to ensure that indigenous plant and animal species and communities survive and flourish.

The goal for water management is to:

Reinstate a more natural flooding regime that protects and enhances the ecological values within the Guttrum and Benwell Forests.

Guttrum and Benwell Forests are comprised of River Red Gum forests and woodlands interspersed with swampy low-lying habitats. These are described as permanent wetlands, semi-permanent wetlands, River Red Gum with flood dependent understorey and River Red Gum with flood tolerant understorey, reflecting the habitat type and flooding regime.

Ecological objectives and targets were developed to reflect the diversity of habitats, the forests' values and functions, and the desired ecological outcomes of enhanced flooding. The overarching objectives for Guttrum and Benwell Forests are for healthy: semi-permanent wetlands; River Red Gum with flood dependent understorey; and native bird community. These combined will deliver outcomes for threatened flora and fauna, and overall healthy functioning floodplain ecosystems.

Proposed supply measure

Guttrum and Benwell Forests are entirely dependent on inflows from the River Murray to maintain the character and health of the floodplain ecosystems. Located downstream of Koondrook, inflows commence when the River Murray, at the Barham gauge, reaches 16,000 ML/d for Guttrum Forest and 15,000 ML/d for Benwell Forest. Under natural conditions flows up to 23,000 ML/d would have occurred every year, causing widespread inundation of the floodplains. With regulation of the River Murray, there has been a significant reduction in both the frequency and duration of flows entering the forests, creating a hydrological deficit (see Table E-1).

Table E-1: Flooding regime deficit of Guttrum and Benwell Forests

Floodplain habitats	Frequency % of years compared to natural	Duration of event % of months compared to natural
Wetlands	75% of natural	50% of natural
Wetlands and River Red Gum forests	50% of natural	75% of natural
Summary for all areas of the forests	**50 to 75% of natural**	**40% of natural**

The flooding regime deficit has created an artificial stressor, resulting in the reduced extent and productivity of the forests' more flood dependent values. This is particularly evident for semi-permanent wetlands, which are being replaced by encroaching River Red Gums, terrestrial and exotic species. Large old trees are also exhibiting stress, with dieback and mortality evident in many. The decline in condition of the vegetation communities reduces the suitability of the forests for many dependent flora and fauna.

To address these ecological impacts, a package of works has been developed to reinstate a more natural flooding regime for the Guttrum and Benwell Forests. The works have been designed to meet the environmental watering requirements of the ecological values by mimicking a 26,000 ML/d flood event in the River Murray for Guttrum Forest, and a 24,000 ML/d flood event for Benwell Forest. Delivery of environmental water via the irrigation channel system will enable watering of the priority habitat types- 99% of the semi-permanent wetlands and 82% of the River Red Gum flood dependent understorey- a total area of 1,200 ha across both forests.

Critical to the infrastructure package design was the ability to provide operational flexibility, minimise footprints, and generate simple, robust and cost effective assets. The proposed works are presented below.

Table E-2: Infrastructure for Guttrum and Benwell Forests

Infrastructure	Function
Guttrum Forest	
Two inlet channels	Deliver environmental water from the Torrumbarry Irrigation Area (TIA).
Regulator and levee works at forest outfall	Contain water, control water levels and provide a fish exit.
Reed Bed Swamp connecting channel	Enhancement of existing natural channel to connect Reed Bed and Little Reed Bed swamps New small regulating structure at Little Reed Bed Swamp to control direction of flow.
Levee works	Contain water on the floodplain. Remedial work to minimise risk to adjacent private land.
Benwell Forest	
One inlet channel	Deliver environmental water from the TIA.
Two regulators and levee works at forest outfalls	Contain water, control water levels, and provide a fish exit.
Levee works	Contain water on the floodplain. Minimise risk to adjacent private land.

The total construction cost for the package of works for both forests is **$28,449,309**. It is noted that cost estimates may decrease during the detailed design phase as the designs are refined and contingency is reduced. Works are scheduled to be complete and operational within four years, from procurement of detailed designs to fully commissioned works.

Ecological Outcomes

Environmental water delivery to the Guttrum and Benwell Forests will generate significant environmental benefits and eliminate the effects of River Murray regulation. Providing a more natural flooding regime through works will: restore the extent and distribution of wetland vegetation and associated fauna such as the nationally vulnerable Growling Grass Frog, provide opportunities for colonial waterbird breeding of threatened species such as the Great Egret and, enhance floodplain productivity generating habitat, food, and breeding opportunities for a diversity of floodplain flora and fauna, on and off the floodplain. Wider benefits to the River Murray and Murray Darling Basin will be realised through enhancing connectivity and extending habitat availability for mobile and resident species.

Addressing risk

As part of the Project, a comprehensive environmental, social and economic risk assessment, compliant with AS/NZS ISO 31000 2009, was undertaken. High priority ecological risks from operation of the measure were identified and include an increase in pest fish, stranding of native fish, colonisation of undesirable plant species, River Red Gum encroachment and blackwater. Associated socio-economic risks include reduced access for social and economic activities. For the Project's development and construction phases, priority risks include fire, injury, loss of corporate knowledge and delays due to approvals or bad weather.

For all priority risks mitigation measures have been identified, to reduce the likelihood and consequence of them occurring.

Implementation of the Project

The local community, Traditional Owners and stakeholders have a strong connection and interest in the Guttrum and Benwell Forests. Engagement of these groups and general communication activities will be a critical component of the successful implementation of the Project. Activities undertaken to date provide a strong foundation for the future, which will be guided by the *Stakeholder Engagement Strategy* and the needs of interested parties.

The Regulatory Governance Group established by DEPI will facilitate the streamlining of the regulatory approvals process. In addition, appropriate governance and project management arrangements will be instituted to minimise risks to investors and other parties from the proposed supply measure.

Conclusion

The *Guttrum and Benwell Environmental Works Project* has the potential to generate significant environmental outcomes through the construction and operation of smart, efficient and cost effective works. The Project demonstrates a high level of scientific rigour and is founded on strong planning, expert input and the significant experience of the community and agencies working in partnership.

1 Introduction

The *Guttrum and Benwell Forests Environmental Works Project* (the Project) has been developed as a supply measure under the Murray-Darling Basin Plan Sustainable Diversion Limit (SDL) adjustment mechanism. The SDL adjustment mechanism enables the use of less water to achieve equivalent environmental outcomes sought by the Basin Plan. The Project is one of nine proposed infrastructure based supply measures being investigated within Victoria, and one of two within the North Central Catchment Management Authority (CMA) region.

The development of this business case has been guided by the *Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases*. The Business Case sets out the ecological objectives, proposed infrastructure package, operating strategies, ecological risks and benefits and the costs associated with progressing the Project through to construction. It has been developed in partnership with the Department of Environment and Primary Industries (DEPI), Parks Victoria and Goulburn Murray Water (GMW).

The primary aim of the Project is to restore the ecological condition of Guttrum and Benwell Forests. The two adjacent forests feature shallow semi-permanent wetlands and River Red Gum (*Eucalyptus camaldulensis*) forest. River regulation has depleted the flooding regime of these high value floodplain habitats, with the frequency and duration of flood events now halved on average compared to natural conditions. The significant reduction in natural flooding has lowered the biodiversity values, reducing the extent of wetlands, and the productivity and habitat value of the River Red Gum forest.

Due to the forests' ecological and hydrological similarities, they are considered together for the purposes of this business case. A package of works has been designed to mimic up to an equivalent of a 26,000 ML/d River Murray flood event in each forest. The package of infrastructure consists of two separate inlets to deliver environmental water into Guttrum Forest, one inlet in Benwell Forest, and works to contain water on the floodplain. These works will enable a maximum area of 719 ha to be inundated in Guttrum Forest and 481 ha in Benwell Forest. The inlets provide operational flexibility to meet the water requirements of the high value water regime classes and reduce potential ecological and operational risks.

The cost to progress this project through detailed designs, statutory approvals and construction is **$28,449,309**.

1.1 Eligibility

Victoria considers that the *Guttrum and Benwell Environmental Works Project* meets the relevant eligibility criteria for Commonwealth supply measure funding.

In accordance with the requirements of the Murray-Darling Basin Plan, Victoria confirms that this is a new supply measure, additional to those included in the benchmark conditions. The operation of this measure will:

- increase the quantity of water available to be taken in the Victorian Murray surface water SDL resource units;
- provide equivalent environmental outcomes with a lower volume of held environmental water than would otherwise be required to be achieved;
- ensure that there are no detrimental impacts on reliability of supply of water to holders of water access rights that are not offset or negated; and
- be designed, implemented and operational by 30 June 2024.

This business case demonstrates in detail how each eligibility requirement is met. However it is noted that this will be dependent on the final outcomes of the modelling work to be completed in 2015 by the Murray-Darling Basin Authority (MDBA).

Other than the provision of financial support to develop this business case, this proposal is not 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 Project Details

2.1 Locality

Guttrum and Benwell Forests, situated on the River Murray floodplain downstream of Koondrook in northern Victoria (Figure 2-1), are River Red Gum floodplain forests of significant ecological importance in the Murray-Darling Basin (MDB). With a combined area of 1,930 hectares they comprise considerable areas of floodplain forest that support rare and threatened species, and stands of large old trees.

The forests are predominantly state forest managed by the Department of Environment and Primary Industries (DEPI), with the linear Murray River Reserve abutting the River Murray managed by Parks Victoria (Figure 2-1). The regional environmental water manager is the North Central CMA and the regional water corporation is GMW.

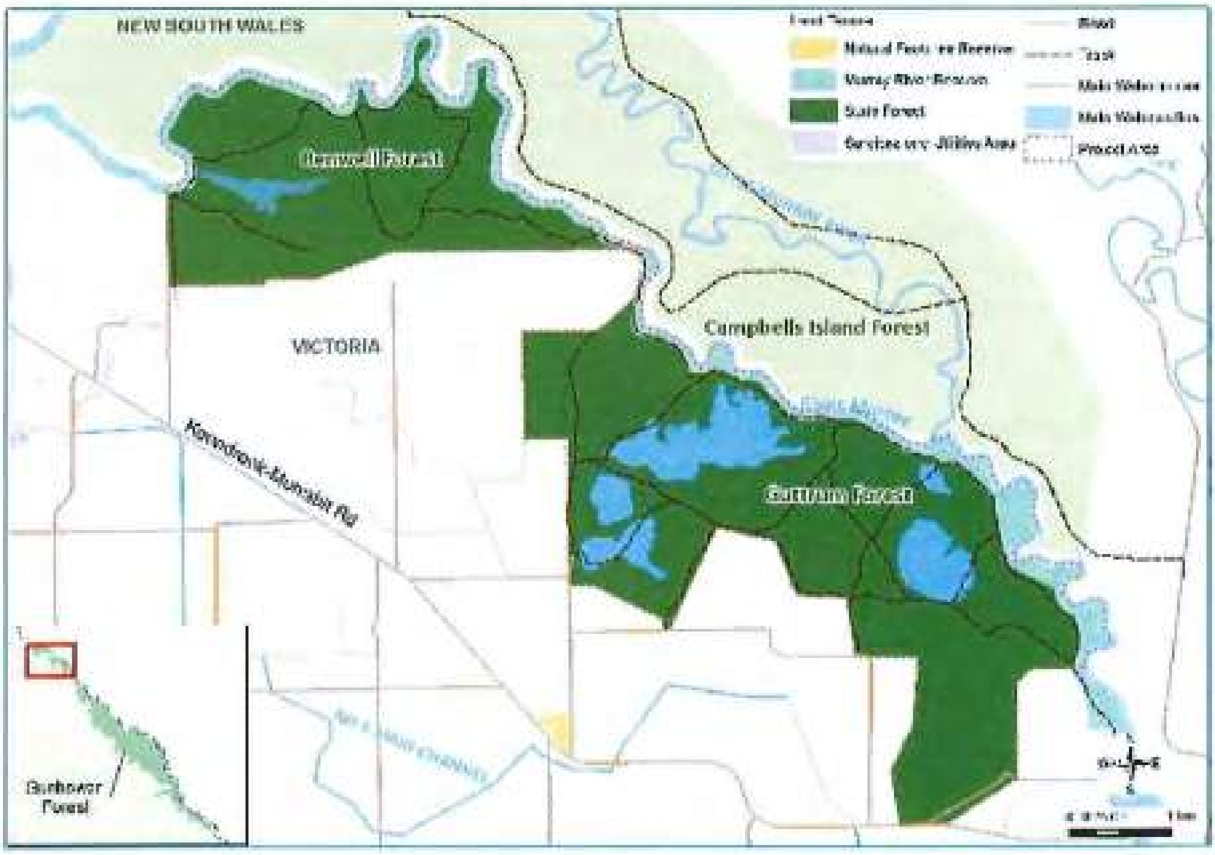


Figure 2-1: Guttrum and Benwell Forests within the broader River Red Gum floodplain system

2.2 Significance

Yellow-footed Antechinus (Photo C. Gray)

River Red Gum floodplain forests, such as Guttrum and Benwell Forests, are of significant ecological importance in the MDB, as they provide essential habitat and resources for a range of aquatic, amphibious and terrestrial fauna (Roberts and Marston 2011). Guttrum and Benwell Forests are two of the few remaining intact River Red Gum swamps in Victoria.

The core ecosystem communities that are influenced by the Project comprise semi-permanent wetlands; River Red Gum forest; native fish and native birds. A wide range of waterbird and woodland species are known to inhabit the forests, with at least 62 species of birds recorded, including important migratory birds covered by international agreements (JAMBA, CAMBA). The forests also provide critical floodplain forest habitat to mammals such as the recently recorded Yellow-footed Antechinus (*Antechinus flavipes*), and threatened amphibians such as the Growling Grass Frog (*Litoria raniformis*) that are listed under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act (1999))*.

2.3 Proposed works package

The purpose of the proposed package of infrastructure is to enable delivery of environmental water to the forests to address the hydrological deficit in the flooding regime caused by river regulation, particularly the reduced frequency and duration of floods. The package has been developed to meet the water requirements of biota in the forests, and prescribes the desired extent of inundation, depth, and duration. The infrastructure has also been designed to minimise environmental and operational risks.

The location of works to deliver the required inundation outcomes in the Guttrum Forest are shown in **Error! Reference source not found.** and in Benwell Forest in **Error! Reference source not found.**. A short description of the package of works is provided below with the full package described in Section 11, and costings provided in Section 13. The *Concept Design report* provides detail on the designs, criteria and drawings (URS 2014).

2.3.1 Guttrum Forest (refer to Figure 2-2 for locations of infrastructure)

G1 and G2 Irrigation Channel Supply: two new and separate irrigation channels (G1 and G2) will connect the forest into the Torrumbarry Irrigation Area (TIA). Irrigation channel supply works will consist of an offtake regulating structure and road and farm drainage culvert/inverted syphon crossings.

G5 New Regulator: a new regulator and raised access track/levee at the forest outlet (G5 New) will replace an old existing structure to contain water on the floodplain, control water levels, and provide a fish exit.

Little Reed Bed – Reed Bed Swamp Connection: the connection between Little Reed Bed and Reed Bed swamps will be improved by enhancing an existing natural effluent, and the inclusion of small regulating structures. This will facilitate the movement of water between the two semi-permanent wetlands when flooding the forest from the irrigation system. A temporary pumping site with permanent access and civil works will also be required to enable the top-up of water levels by pumping from the River Murray.

Guttrum Perimeter Levee: depending on the preferred option, works may consist of repairs to the existing perimeter levee and new levee sections for high 'consequence of failure' points on the north western forest boundary.

Access tracks: required for existing perimeter levee monitoring and maintenance along private property and within the forests.

G5 Old Erosion Protection Works: protecting the existing bridge, channel and outfall at G5 Old during a natural flood event or high river the flows with erosion protection.

Figure 2-2: Proposed package of infrastructure to deliver environmental water to Guttrum Forest

2.3.2 Benwell Forest (refer to Figure 2-3 for locations of infrastructure)

B1 Irrigation Channel Supply: a new irrigation channel connection (B1) will connect the forest into the TIA. Irrigation channel supply works include a channel offtake and forest outfall regulating structure and road and farm drainage culvert/inverted syphon crossings.

B13 Regulator: a new regulator (B13 regulator), primary spillway weir, vehicle crossing and raised forest access track/levee (B13 levee) on the natural forest effluent at B13 to contain water on the floodplain.

B7 Culvert Crossing: a small culvert river track crossing of the natural forest effluent channel at B7, with an automated dual-leaf gate (B7 outlet and culvert) to contain water on the floodplain and provide accurate water release control for through-flows.

Benwell Levee: depending on the preferred option, works may consist of repairs to the existing perimeter levee, or new levee sections for all 'high consequence of failure' points on the north western forest boundary.

Access tracks: required for existing perimeter levee monitoring and maintenance along private property and within the forest.

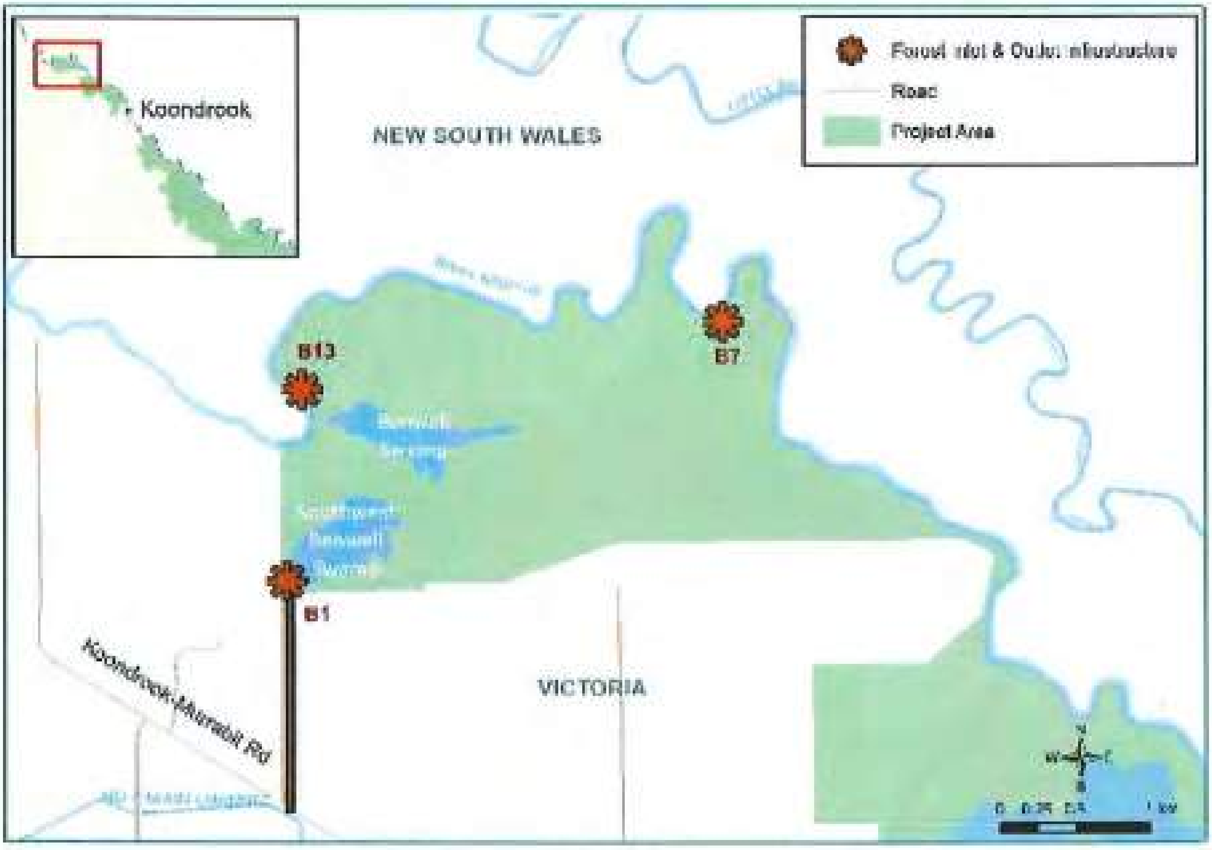


Figure 2-3: Proposed package of infrastructure to deliver environmental water to Benwell Forest

The combination of these works will enable the delivery and containment of flood water on the forests' floodplain, and the provision of supplementary flows to wetlands to extend the duration of inundation, as required. The inlet channels will deliver water from the TIA. Preliminary investigations were undertaken to determine the viablity of being able to deliver required volumes of environmental water when required, and within the constraints of the system. Results indicate that free capacity does exist virtually all year round at the required location. Further modelling work however will be required to explore any potential constraints in other years, as modelling was undertaken on one particular year, selected because it was dry, and there was a high level of customer deliveries.

2.4 Summary of costs and proposed schedule

The proposed schedule of works and costs is presented in Table 2-1, showing a total capital construction cost of **$28,449,309** and a planning, construction and commissioning period of four years.

Table 2-1: Project schedule

Stages	Year 1	Year 2	Year 3	Year 4
Planning/Detailed design				
Approvals				
Procurement				
Works				
Commissioning				

2.6 Proponent and proposed implementing entity

The feasibility study and business case for the proposed supply measure has been developed by the North Central CMA, on behalf of the Victorian Government and in partnership with DEPI, Parks Victoria and GMW, through funding from the Commonwealth Government.

As the project owner, DEPI will have oversight responsibility for project implementation, pending confirmation of construction funding. Further information regarding the proposed governance and project management arrangements for implementation is provided in Section 16.

3 Values of the Sites

3.1 Ecological values

Guttrum and Benwell Forests provide a diversity of habitats including River Red Gum floodplain forest and woodland ecosystems, and complexes of shallow semi-permanent wetlands. The semi-permanent wetlands, or swamps, are characterised by open water, marshland, reed bed and herbland vegetation, fringed with River Red Gum. Both forest ecosystems, as a whole, are classified as a freshwater meadow containing areas of shallow marsh (Corrick and Norman 1994 in DSE 2007), a classification that is considered valuable due to the dramatic loss in its extent since European settlement (NRE 1997).

The forests support a wide range of water-dependent communities and species; many listed as rare or threatened under state and national legislation, and contain representative floodplain vegetation (Bennetts 2014). The following sections provide an overview of the significant values and Appendix 1 is a full listing of recorded flora and fauna species. Of note, a greater abundance and diversity of species is expected to be present in the Guttrum and Benwell Forests than has officially been recorded to date. This is due to limited historical survey effort and their similarity to other floodplain systems that are considered biodiversity 'hotspots' for native flora and fauna (e.g. Gunbower Forest).

3.1.1 Vegetation communities

Guttrum and Benwell Forests are located within the Murray Fans Bioregion, one of three bioregions along the Murray River floodplain downstream of the Ovens junction, and part of the Riverina Interim Biogeographic Regionalisation for Australia bioregion. The Murray Fans supports a mosaic of Plains Grassy Woodland, Pine Box Woodland, Riverina Plains Grassy Woodland and Riverina Grassy Woodland Ecological Vegetation Classes (VEAC 2008). Located within the broad vegetation type of the Riverine Grassy Woodland Complex (SKM 2007), they help to maintain the ecological diversity of the bioregion by supporting vegetation communities representative of it.

Vegetation communities within Guttrum and Benwell Forests have been mapped and classified into Ecological Vegetation Classes (EVCs). EVCs are the standard Victorian classification unit, which groups floristic communities occurring across biogeographic ranges within specific environmental niches.

Seven EVCs, two EVC aggregates and one EVC complex are present within the forests, all of which are threatened in Victoria. A list of the EVCs and their relative conservation status is presented in Table 3-1. The distribution of recently mapped EVCs are shown in Figure 3-1 and Figure 3-2.

Table 3-1: Ecological Vegetation Classes within Guttrum and Benwell Forests.

Ecological Vegetation Class	Conservation Status (DEPI 2014)
EVC 819 Spike-sedge Wetland	Vulnerable
EVC 653 – Aquatic Herbland	Depleted
EVC 815 – Riverine Swampy Woodland	Vulnerable
EVC 814 – Riverine Swamp Forest	Depleted
EVC 945/8124 – Floodway Pond Herbland/Riverine Swamp Forest Complex[1]	Depleted
EVC 295 – Riverine Grassy Woodland	Vulnerable
EVC 106 – Grassy Riverine Forest	Depleted
EVC 56 – Floodplain Riparian Woodland	Depleted
EVC 816 – Sedgy Riverine Forest	Depleted
Floodplain Wetland Aggregate[2]	-
Billabong Aggregate	-

The EVC complex – Floodway Pond Herbland/Riverine Swamp Forest Complex – represents areas of the two EVCs occurring in a mosaic, making it difficult to separate at a larger scale for mapping purposes.

The EVC aggregates present are areas that, at the time of mapping, represented one EVC but would be expected to change considerably under different hydrological conditions (Biosis 2014b). They are therefore mapped as aggregates to encompass the dynamic characteristics of these areas.

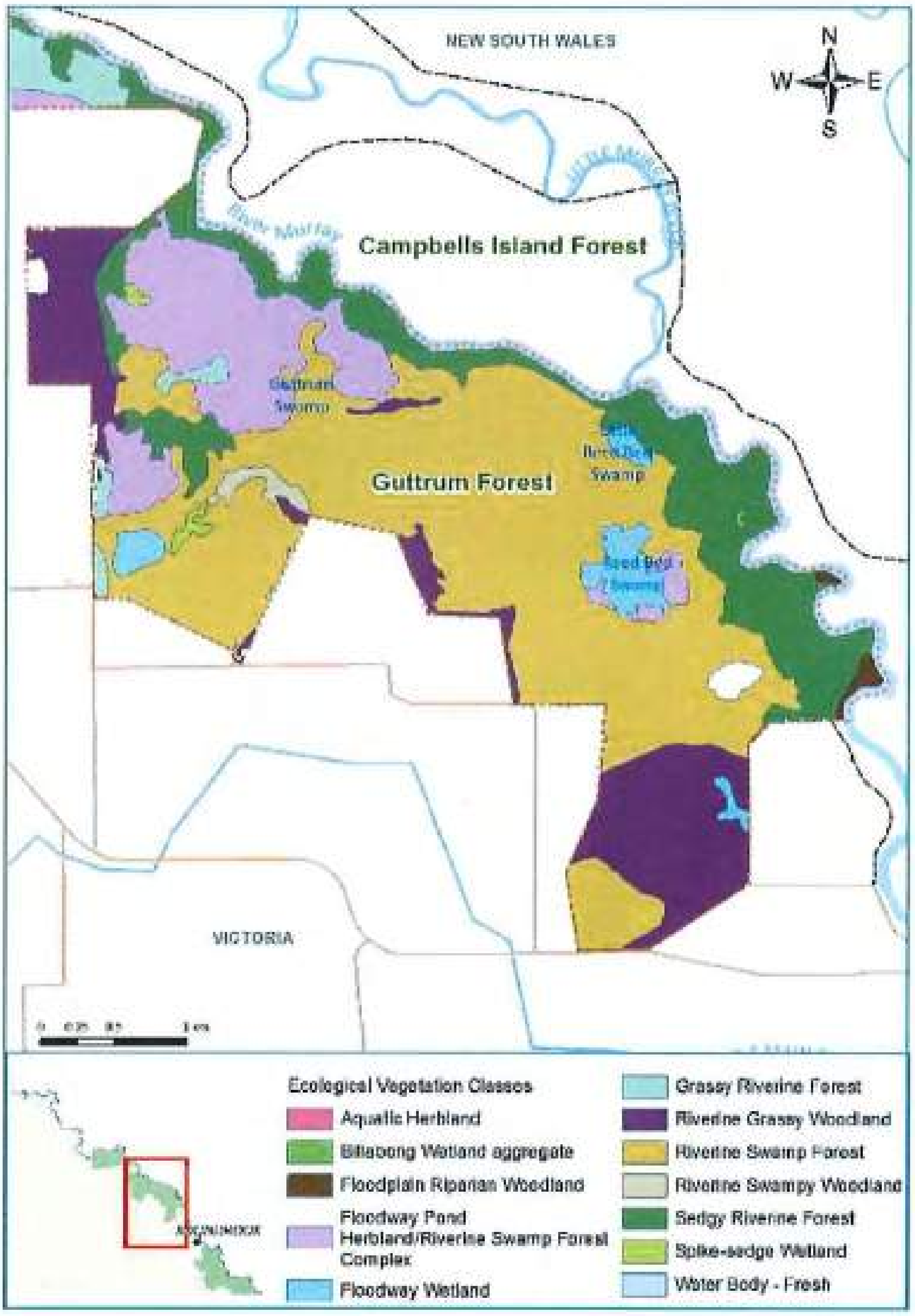


Figure 3-1. Ecological Vegetation Classes in Guttrum Forest

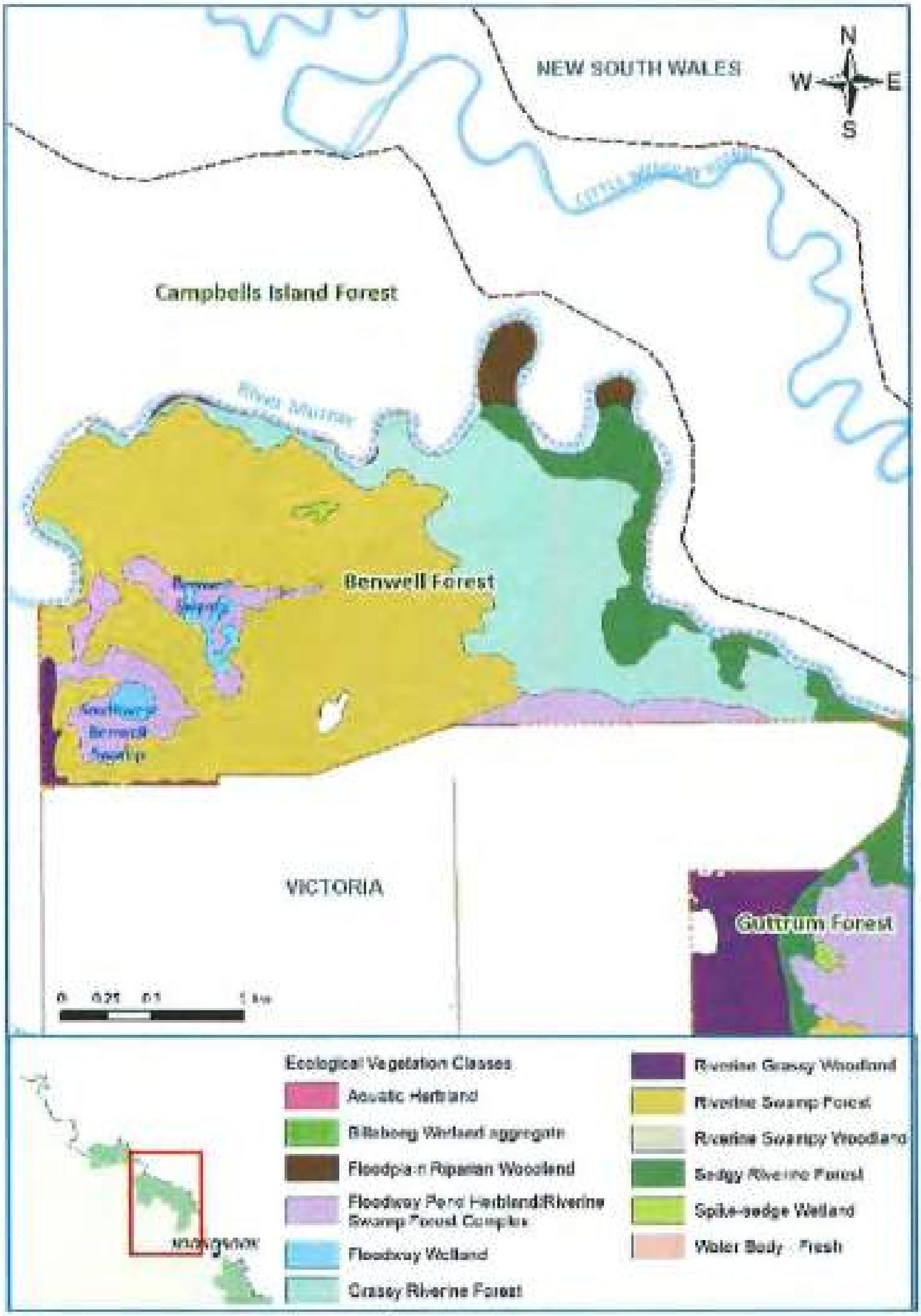


Figure 3-2. Ecological Vegetation Classes in Benwell Forest

3.1.2 Flora

One hundred and twelve species of native flora have been recorded in the Guttrum and Benwell Forests. This includes water-dependent wetland species listed under the *EPBC Act (1999)* such as River Swamp Wallaby Grass (*Amphibromus fluitans*), and the *Flora and Fauna Guarantee Act 1988* (*FFG Act* (1988)) such as the threatened Wavy Marshwort (*Nymphoides crenata*). Eighteen species are listed as protected under the *FFG Act* (1988) (public land only) and a further five species are on the DEPI Advisory List of Rare or Threatened Plants in Victoria (2014). The list of species for Guttrum and Benwell Forests is a compilation from four separate studies (SKM 2007; Biosis 2014a; Biosis 2014b; Bennetts 2014) and the Victorian Biodiversity Atlas (DSE 2010). Given the similarity in vegetation and hydrological conditions to the nearby Gunbower Forest, it is likely that one or more of the other 36 rare and threatened species found there in the last decade would be present in Guttrum and Benwell Forests (Bennetts 2014).

Wavy Marshwort (Photo A.Russell)

River Swamp Wallaby Grass (Photo A.Russell)

In addition to the many rare and threatened species, Guttrum and Benwell Forests are host to numerous large old River Red Gums (>100cm DBH) that were established prior to European settlement. The age and size of these trees is significant, as in other nearby River Red Gum forests such as Gunbower Forest, most of these trees have been harvested or ringbarked to promote mill timber (Bennetts 2014). Healthy trees of this stature provide valuable habitat for birds and marsupials (Biosis 2014b), and have a key role in maintaining the diversity of ground- and understorey, species by outcompeting other saplings and maintaining the open, widely spaced woodland character of the forests (Bennetts, K 2014 personal communication, 9 October).

Large old River Red Gum in Benwell Forest

3.1.3 Native birds

A wide range of waterbird and woodland species is known to make use of Guttrum and Benwell Forests, with 91 species recorded (Disher 2000; DSE 2010; Biosis 2014a; Bennetts 2014). This includes waterbirds such as the EPBC-listed Australasian Bittern (*Botaurus poiciloptilus*) and the FFG-listed Little Egret (*Egretta garzetta*) and Intermediate Egret (*Ardea intermedia*), which are considered endangered in Victoria (DEPI Advisory List 2013). In addition, the forests have historically supported migratory waterbirds protected through the Japan-Australia Migratory Bird Agreement (JAMBA) and China-Australia Migratory Bird Agreement (CAMBA): the White-bellied Sea Eagle (*Haliaeetus leucogaster*) and Eastern Great Egret (*Ardea modesta*). Both species are also listed as threatened in the *FFG Act* (1988) with the Great Egret also listed as vulnerable under the *EPBC Act* (1999).

Historically, the forests have provided conditions suitable for waterbird feeding and breeding (Ecological Associates 2013). Guttrum Forest has provided regionally important breeding habitat for colonial nesting species in and around Reed Bed Swamp (Ecological Associates 2013). More recently, evidence of colonial nesting species has been found in South-west Benwell Swamp, which is expected to have occurred in the 2010-11 floods. A number of waterfowl have been recorded within the forests, including the Australian Shelduck (*Tadorna tadornoides*) and the Black Swan (*Cygnus atratus*) (DSE 2010). A range of waterbirds, including colonial nesting species and waterfowl are present in the farmland adjacent to the forests, and it is likely that these return to the two forests when conditions are suitable (Bennetts 2014).

Australasian Bittern (Photo J.Barkla BirdLife Australia)

Great Egret (Photo D.Kleinert)

Many woodland birds are associated with floodplain forests, using them for habitat, foraging, breeding and watering (Johnson et al. 2007). Guttrum and Benwell Forests support a number of these, listed in the *FFG Act* (1988) Victorian Temperate Woodland Bird Community, such as the recently sighted Diamond Firetail (*Stagonopleura* guttata), endangered (in Victoria) Grey Crowned Babbler (*Pomatostomus temporalis*), and the near-threatened Brown Treecreeper (*Climacteris picumnus victoriae*) on the DEPI Advisory List of Rare or Threatened Vertebrate Fauna in Victoria (2013) (Bennetts 2014). A group of Grey Crowned Babblers nest on the edges of both forests in River Red Gums, part of one of the strongest remaining populations in Victoria. Overall this species has declined by about 90 per cent since pre-European settlement (Tzaros et al. 2014).

Diamond Firetail (Photo North Central CMA)

Grey Crowned Babbler (Photo A.Martins)

3.1.4 Amphibians and reptiles

The habitats across the forests support a number of native frogs and reptiles, including the nationally vulnerable Growling Grass Frog recorded within and around Benwell Forest, and would have benefited from the dense reedy vegetation and sustained flooding that previously existed in the semi-permanent wetlands (Ecological Associates 2013; DSE 2010). The FFG-listed Brown Toadlet (*Pseudophryne bibronii*) and the Barking Marsh Frog (*Limnodynastes fletcheri*) were historically recorded within a 5 km buffer zone and are both on the DEPI Advisory List of Rare or Threatened Vertebrate Fauna in Victoria (2013). Anecdotal evidence suggests that the FFG-listed Carpet Python (*Morelia spilota metcalfei*) has been in the forests within the last decade, and ecologists have indicated that habitats would be highly suitable for this species (Biosis 2014a).

Two other water-dependent vertebrate species have been recorded within and adjacent to the forests. These are the Broad-shelled Turtle (*Chelodina expansa*) and the Common Long-necked Turtle (*Chelodina longicollis*). The Broad-shelled Turtle is listed under the *FFG Act* (1988) and as endangered on the advisory list of rare or threatened vertebrate fauna in Victoria (DEPI 2013). The Common Long-necked Turtle is listed as data deficient on the advisory list of rare or threatened vertebrate fauna in Victoria (DEPI 2013).

Growling Grass Frog (Photo N.Layne)

Common Long-necked Turtle (Photo B. Velik-Lord)

3.1.5 Mammals

The forests also provide critical floodplain forest habitat to mammals, such as the historically recorded FFG-listed Sugar Glider (*Petaurus breviceps*) and the recently recorded Yellow-footed Antechinus (Biosis 2014a), whose preferential habitat is in decline (Lada and Mac Nally 2008).

3.1.6 Native fish

The local River Murray community supports 13 recorded native fish species, a number of which are listed under the *FFG Act* (1988) and the *EPBC Act* (1999). This includes large-bodied fish such as the nationally vulnerable Murray Cod (*Maccullochella peelii*) and the endangered Trout Cod (*Maccullochella macquariensis*) (North Central CMA 2014a). Ecological monitoring studies are required to confirm the presence of fish utilising the floodplain in Guttrum and Benwell Forests, though it is expected that these large-bodied species would move onto the floodplain during natural inundation events as they have been known to do in nearby Gunbower Forest (Chatfield, A 2014, personal communication, 5 November). In addition, a number of small-bodied fish are present in the area that would opportunistically access the semi-permanent wetland habitat within the forests during natural flooding, such as Carp Gudgeon (*Hypseleotris spp.)* and the FFG-listed Un-specked Hardyhead (*Craterocephalus stercusmuscarum fulvus*).

3.1.7 Ecological Functions

Guttrum and Benwell Forests comprise approximately 1,930 hectares of River Red Gum forests and semi-permanent wetlands, and are an integral part of the River Murray floodplain performing a number of ecosystem functions. At a local (site-specific) level, the forests are critical in supporting water-dependent values, including but not limited to:

Food production- The conversion of matter to energy for uptake by biota, including substrate surfaces (i.e. rocks, woody debris, gravel) for biofilms and plant matter, and interactions between primary producers and consumers such as the breakdown of carbon and nutrients by zooplankton and macroinvertebrates for higher order consumers.

Provision of shade and shelter for biota- The forests, ephemeral wetlands and shallow mudflats provide drought refuge, and feeding and breeding habitat for waterbirds, frogs and turtles.

Provision of water for consumption- Retention and storage of water for biota to enhance growth and development and to ensure survival and reproduction.

At a regional (complex) level, Guttrum and Benwell Forests are critical to support water-dependent values, including but not limited to:

Movement/dispersal- Mobile species move to access resources such as food, breeding habitat and mates. This assists with maintaining genetic diversity within the landscape and reduces the risk of local species extinction. Movement also supports the dispersal of seeds/progapules in the landscape providing a source for colonisation.

Cycling nutrients and storing carbon- After flooding, water drains off the floodplain back to the River Murray, providing critical carbon and food sources for aquatic fauna including native fish populations. In particular, this connectivity provides an important food source for channel specialist and generalist fish species in the local River Murray fish community, and may enhance conditions for spawning and recruitment (Humphries et al. 1999).

Biological diversity- The provision of a sufficient number and range of habitat types in the landscape supports a diversity of native species. This in turn assists to safeguard the region from the impacts of local catastrophic events (i.e. loss of habitat through fire and clearing) due to there being sufficient alternative habitats available.

3.2 Water regime classes

As outlined in Section 3.1 the Guttrum and Benwell Forests contain a range of significant flora and fauna values within seven EVCs mapped for the forests. To facilitate the development of ecological objectives and watering targets and correlate the EVCs and values with flooding regimes, 'water regime classes' have been developed (Ecological Associates 2013). The relationship between EVCs and the forests' water regime classes is provided in Table 3-2.

Water regime classes (WRCs) were developed using a range of sources such as LiDAR, historical hydrological modelling and EVC mapping, and represent the hydrological requirements of vegetation that is expected to be present under a natural flooding regime. Four water regime classes are identified: permanent or semi-permanent wetlands, and River Red Gum forest with either flood dependent or flood tolerant understorey (refer Table 3-2). Water regime classes are described briefly in this section, and in further detail in Appendix 2.The distribution of WRCs in both forests is shown in Figure 3-3 and Figure 3-4.

Table 3-2: Water Regime Classes in Guttrum and Benwell Forests (Ecological Associates 2013)

Water Regime Class	Guttrum (ha)	Benwell (ha)	High value EVCs
Permanent wetlands	2.3	0	Billabong Aggregate
Semi-permanent wetlands	224	65	EVC 819 – Spike-sedge Wetland EVC 653 – Aquatic Herbland Floodway Wetland Aggregate
RRG: flood-dependent understorey	642	356	EVC 815 – Riverine Swampy Woodland EVC 814 – Riverine Swamp Forest EVC 945/814 – Floodway Pond Herbland/Riverine Swamp Forest Complex
RRG: flood-tolerant understorey	391	225	EVC 295 – Riverine Grassy Woodland EVC 56 – Floodplain Riparian Woodland EVC 106 – Grassy Riverine Forest EVC 816 – Sedgy Riverine Forest

3.2.1 Permanent wetlands

A small billabong is located in Guttrum Forest to the east of Reed Bed Swamp and is the only permanent wetland in both forests. The billabong is small in extent and makes a small contribution to the habitat diversity of the forest compared to other wetlands. The steep sides of the billabong present limited habitat for emergent macrophytes, and subsequently provide little habitat for wading birds, although waterfowl may feed and roost within and nearby (Ecological Associates 2013).

3.2.2 Semi-permanent wetlands

Two large semi-permanent wetland complexes are located in Guttrum Forest - Guttrum Swamp and Reed Bed Swamp (including Little Reed Bed). Benwell Forest has two semi-permanent wetland complexes, Benwell Swamp and the smaller Southwest Benwell Swamp. These wetlands provide a diverse range of habitats including shallow marsh, open water, reed beds and herbland. River Red Gum would normally be excluded by prolonged flooding. Although water is usually present, the wetlands dry out occasionally. Spring flooding promotes macrophytes such as Marsh Club-sedge (*Bolboschoenus medianus*) and Common Water-ribbons (*Triglochin* spp.), while the deeper wetlands that remain inundated into summer and autumn would be dominated by rushes and reeds such as Common Reed (*Phragmites australis*) and Giant Rush (*Juncus ingens*). Wetland fringes support herblands and low-growing emergent species such as watermilfoils (*Myriophyllum* spp.) and Lesser Joyweed (*Alternanthera denticulata*).

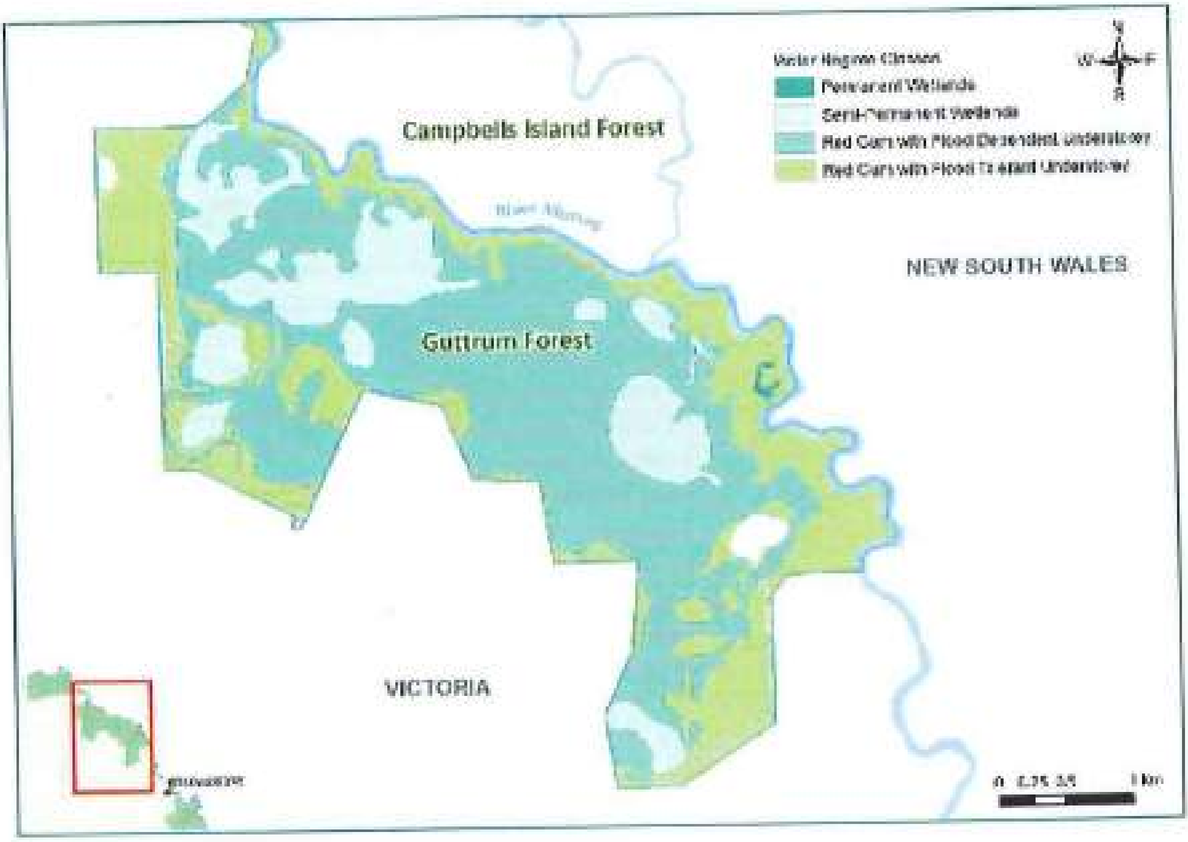


Figure 3-3: Distribution of WRCs across Guttrum Forest

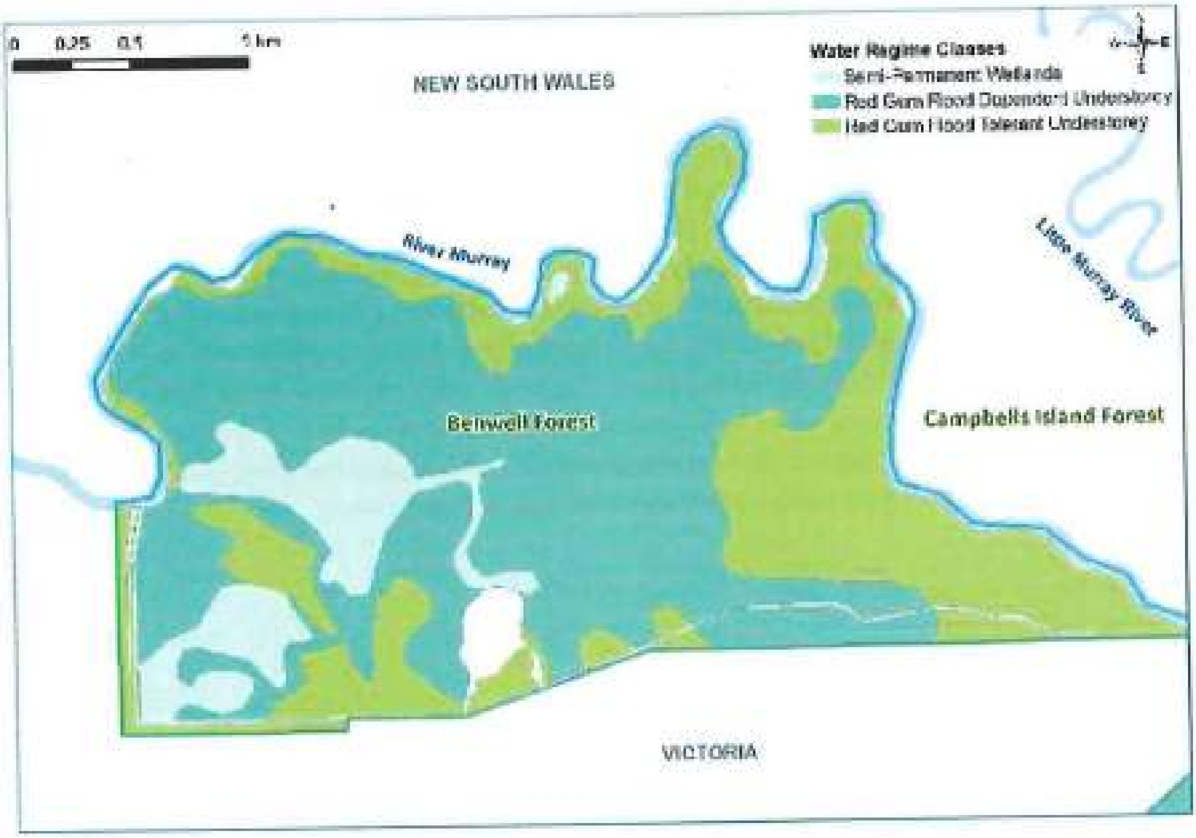


Figure 3-4: Distribution of WRCs across Benwell Forest

The diversity of habitats provided by the semi-permanent wetlands supports numerous waterbirds, providing shelter, nesting habitat and food sources. Flooded reedy habitat provides habitat for frogs and birds such as bitterns and crakes (Ecological Associates 2014). The seasonal inundation and recession of floodwater stimulates microbial and planktonic productivity, supporting higher-order species in the food web such as aquatic invertebrates, frogs and small fish, which in turn are an important food source for waterbirds. The fringing River Red Gums also provide important nesting habitat, particularly for colonial waterbirds.

Aquatic herbland within Benwell Swamp (Photo G. Smith)

3.2.3 River Red Gum with flood-dependent understorey

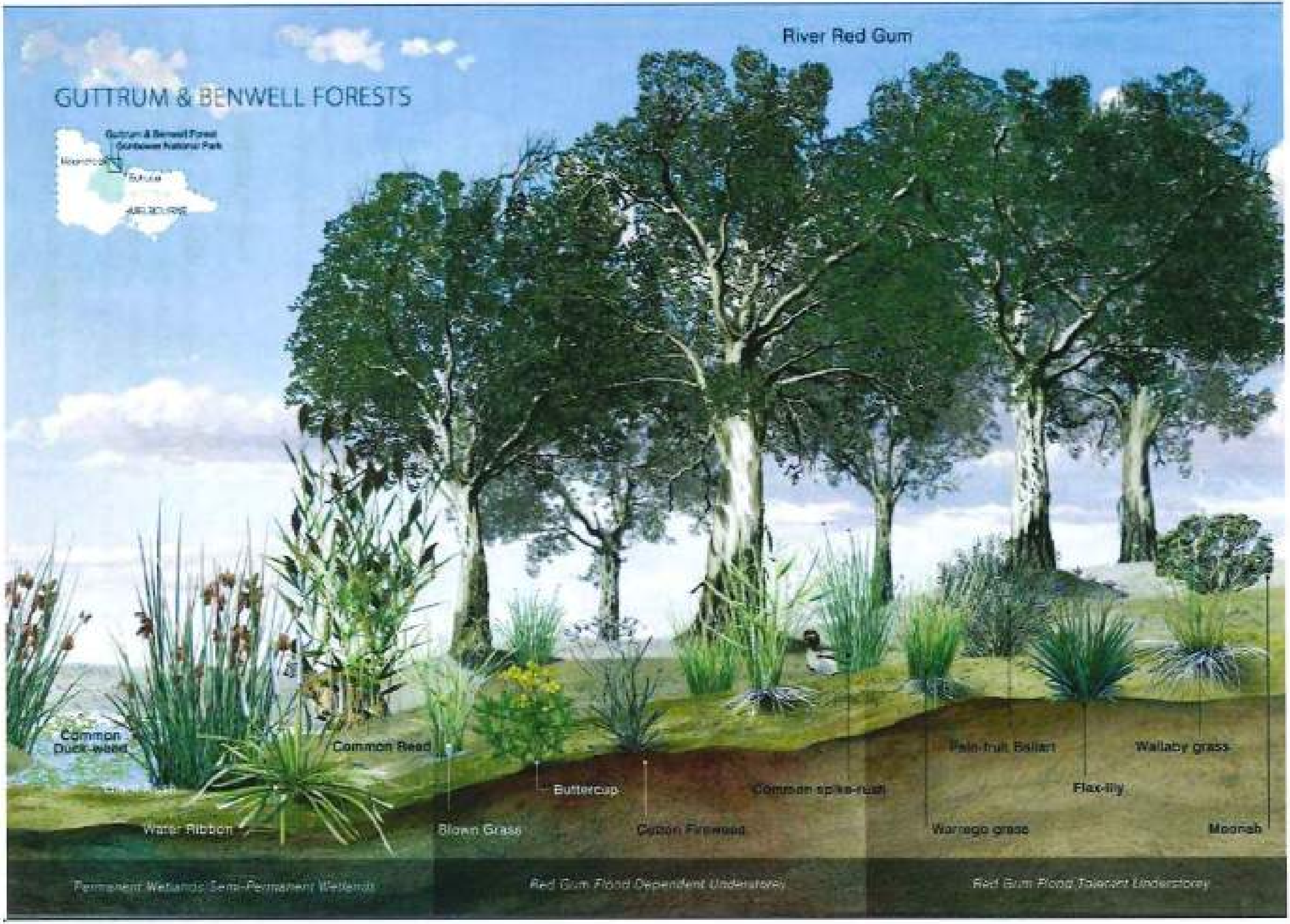
River Red Gum with flood-dependent understorey (FDU) occurs in Guttrum and Benwell Forests in areas which have a low flooding threshold but do not retain deep water when floodwater recedes. This WRC typically supports dense forest and occurs in low lying, frequently flooded areas and often adjoins wetlands. The understorey is dominated by grassy perennial species that require seasonal flooding, combined with rushes and reeds in local depressions. Submerged aquatic macrophytes appear during winter and spring flooding, but die off as the forest dries out. This WRC is distinguished from River Red Gum with flood-tolerant understorey by the dominance of ground flora that require flooding to complete their lifecycle (i.e. Water Ribbons (*Triglochin spp.*), Common Spike-sedge (*Eleocharis acuta*) and Warrego Summer-grass (*Paspalidium jubiflorum*) (URS 2001).

River Red Gum Forest FDU (Photo: M. Cooling)

When flooded, this WRC provides important seasonal floodplain habitat for aquatic fauna such as frogs and fish, which disperse from refuge habitat and breed in large numbers. Waterbirds, including waders, will make use of the abundant prey in the flooded understorey. Flooding also initiates the germination of a range of aquatic plants, increasing the flora diversity of the forest. Understorey plant growth persists for several months after flooding and contributes to the productivity of the forests (Ecological Associates 2014). Damp soil conditions from receding floodwater will promote grasses that provide food sources for woodland fauna including herbivores and granivores (such as the Diamond Firetail (*Stagonopleura guttata*)) (Ecological Associates 2014). Understorey vegetation also provides seeds, fruit and forage for granivores, while trees support nectivorous and omnivorous birds. Both overstorey and understorey support insect production on which a range of birds and reptiles depend.

3.2.4 River Red Gum with flood-tolerant understorey

River Red Gum with flood-tolerant understorey (FTU) occurs on the elevated floodplain floor, along the natural levee formed on the river bank in Guttrum and Benwell Forests. Vegetation includes the drier, more elevated spectrum of the trees' floodplain continuum. This WRC is thought to flood less often, for shorter periods and at shallower depths than the River Red Gum FDU and is hence typified by an understorey that is more independent of flooding (URS 2001). Typical understorey species are Small Spike-sedge (*Elecharis pusilla*), Common Swamp Wallaby-grass (*Amphibromus nervosus*), Ruby Saltbush (*Enchylaena* tomentosa) and Pale Fruit Ballart (*Exocarpus strictus*). Some understorey species along the river levee are more water-dependent, but may be accessing additional soil water along the river bank (Ecological Associates 2013).



An artist's impression of water regime class progression across the landscape in Guttrum and Benwell Forests

3.3 Social and economic values

Guttrum and Benwell Forests are multi-use forests providing both direct and indirect social and economic benefits. Commercial uses include timber production and domestic timber collection, as part of the mid-Murray Forest Management Plan Area, domestic stock grazing, apiculture (bee keeping), and sand mining. Social and recreational uses include dispersed camping, horse riding, hunting, four-wheel driving, bird-watching and sightseeing pursuits.

3.4 Cultural values

The Guttrum and Benwell Forests contain evidence of both Aboriginal and European activities. Both forests comprise areas that are culturally significant to the Traditional Owners. The archaeological assemblage is characterised by a dominance of mounds/earth features with known burial sites, artefact scatters and scar trees recorded in the Aboriginal Cultural Heritage Register Information System (ACHRIS) database (GHD 2011). However, many archaeological sites across the forest have become damaged or lost from past land use activities, including stock grazing and timber harvesting. The historical frequency of flooding may also have reduced the quality and number of sites remaining in the Guttrum and Benwell Forests.

Discussions with Traditional Owners has confirmed the high value they place on restoring the habitat of the forests by reinstating natural flooding frequency.

Scar Tree located in Benwell Forest (Photo A.Chatfield)

3.5 Threats to values

The Guttrum and Benwell Forests are located in an area of low rainfall and high evapotranspiration. The average annual rainfall is less than 400 mm/yr, with evapotranspiration of around 1,700 mm/yr. This creates a significant annual water deficit and means that the health, growth and existence of the forest ecosystems are dependent on regular winter-spring inundation from high river flows (VEAC 2008). In the absence of these flows, the deficit presents a significant stressor for the forests (MDBA 2012).

River regulation and diversion of River Murray flows has resulted in a change in the flooding regimes of Guttrum and Benwell Forests. The frequency and duration of flooding has been reduced and the interval between events has, at times, stretched beyond the thresholds of tolerance for floodplain vegetation (see Section 8), further exacerbating the existing water deficit.

If no active management intervention is implemented to restore a more natural flooding regime and alleviate water stress, the following is likely to continue (SKM 2007, Ecological Associates 2013, Bennetts 2014, Biosis 2014b):

- River Red Gum health will decline in forested areas of the forest
- Encroachment of terrestrial species, including River Red Gums, into semi-permanent wetlands reducing the extent of wetland habitats
- Exotic terrestrial species will be disproportionally favoured by the altered flooding regime compared with native species
- Wetland habitat values will not be optimised for native fauna including a number of threatened species
- Waterbird breeding events will be rare and of a limited size, threatening the viability of existing populations and the resilience of species to additional stressors
- A reduction in organic input from the floodplain to the River Murray.

The provision of a more natural flooding regime is expected to assist in managing a number of these threats and improve the condition and resilience of ecological values within the forests.

Other potential threats to the condition of Guttrum and Benwell Forests are pest plants and animals, and land management practices such as domestic stock grazing and timber harvesting. This is discussed in Section 12.2.

4 Ecological Objectives and Targets

4.1 Vision for Guttrum and Benwell Forests

The vision for Guttrum and Benwell Forests is to:

Maintain and restore healthy floodplain communities across Guttrum and Benwell Forests, to ensure that indigenous plant and animal species and communities survive and flourish.

The goal for water management in the forests is to:

Reinstate a more natural flooding regime that protects and enhances the ecological values within the Guttrum and Benwell Forests.

4.2 Objective development

A suite of ecological objectives and targets were developed for Guttrum and Benwell Forests that represent the desired ecological outcomes of enhanced flooding. These consider the current condition of ecological values and whether intervention is required; and interdependencies within and between these forests and other regional forests such as Campbells Island, and the Gunbower-Koondrook-Perricoota Icon sites. Although Guttrum and Benwell Forests involve independent works, their proximity to each other and their similarity in values and condition mean that the ecological objectives and targets are representative and applicable to both sites.

Development of the ecological objectives was supported by a range of sources to identify the hydrological requirements of ecological values in the forests. These sources included a review of the literature (North Central CMA 2014a, 2014b); ecological and hydrological investigations and modelling to identify water regime classes (SKM 2007; Ecological Associates 2013; Bennetts 2014; Biosis 2014a, 2014b); consideration of previous experience in The Living Murray program for the nearby Gunbower Forest and; a workshop including key stakeholders (North Central CMA 2014a, 2014b). These objectives have been further refined as information has become available and have been subject to peer review. For further information see the *Ecological Objectives and Hydrological Requirements Justification Papers* for both Guttrum and Benwell Forests (North Central CMA 2014a, 2014b).

4.3 Ecological objectives and targets

The draft ecological objectives and associated targets for water management in Guttrum and Benwell Forests are presented in Table 4-1. The overarching objectives state the high-level broad intentions, while the targets represent measurable and achievable outcomes within the given timeframe that will ensure the objective(s) is achieved. The targets focus on measuring the endpoints for each objective, rather than a percentage change from a set benchmark. Every target however has a defined baseline or benchmark e.g. semi-permanent wetlands – at present there are 0% receiving an optimal flooding regime, but under the proposed Project there will be >95% receiving an optimal flooding regime by 2040. It is anticipated that these targets will be tested and refined once the proposed supply measure is operational.

Specific ecological objectives underpinning the overarching objectives have been described for the *Guttrum and Benwell Forest Environmental Works Project* (North Central CMA 2014a, 2014b). A summary is provided below for each of the corresponding overarching objectives. The specific objectives identify a collection of ecological components based on the ecological values of the sites – for example habitat for Growling Grass Frog – and are considered integral to the restoration of a 'healthy' floodplain community. These then link to monitoring methods and reporting against targets. Monitoring methods and targets are further described in the *Guttrum Forest & Benwell Forest Environmental Works Project Monitoring and Evaluation Plan*, as well as reference points or baseline data that targets will be measured against.

Several of the targets reference a completion date of 2040. This date was selected to account for the time required to confirm and construct the project, as well as the current state of ecological values and potential time-lag between environmental water delivery and outcomes being apparent and measurable.

4.3.1 Semi-permanent wetlands

The overarching objective is for 'Healthy semi-permanent wetlands'. Specific ecological objectives for semi-permanent wetlands include:

- achieving appropriate cover and diversity of species
- reducing River Red Gum encroachment
- providing suitable habitat for threatened flora species
- maintaining and where possible, increasing the diversity of threatened flora species
- reducing the area of high threat weed species.

4.3.2 Native birds

The overarching objective is for 'Healthy wetland bird community through improved access to food and habitat that promotes breeding and recruitment'. Specific ecological objectives for native birds include:

- supporting a suite (diversity and abundance) of water birds including waterfowl, colonial waterbirds and other wetland-dependent species
- providing foraging areas for colonial waterbirds
- providing suitable habitat for threatened species
- maintaining and where possible, increasing the diversity of threatened species.

4.3.3 River Red Gum FDU

The overarching objective is for 'Healthy River Red Gum FDU and temporary wetlands'. Specific ecological objectives for River Red Gum FDU include:

- achieving appropriate cover and diversity of understorey species
- improving canopy condition in River Red Gums
- maintaining and where possible, increasing the diversity of threatened species
- reducing the area of high threat weed species.

Table 4-1: Ecological objectives and draft targets for Guttrum and Benwell Forests Environmental Works Project (North Central CMA 2014a; 2014b)

Objectives (by 2040)	Draft Targets (by 2040)	Applicable water-dependent values
SEMI-PERMANENT WETLANDS (SPW)		
• Restore the health of semi-permanent wetlands	• S1: >95% of SPW with a flooding regime that maximises healthy condition by 2040. • S2: At least 75% of wetland transects with 'moderate to excellent' vegetation condition as defined by TLM wetland and floodplain condition assessment categories. • S3: Plant Functional Groups 1-7 >50% of total cover occupied by at least 2/3 of all species possible within these Plant Functional Groups. • S4: River Red Gum encroachment absent. • S5: Presence of habitat suitable for the EPBC-listed Growling Grass Frog. i.e. water with diverse habitat including emergent, submerged and floating vegetation within the September to March breeding period in at least 7 years in 10 (e.g. Reed Bed Swamp, Benwell Swamp). • S6: >50% of threatened species previously recorded observed. • S7: High threat exotic plants absent in >90% of total cover.	• Rare freshwater meadow with diverse habitats • Nationally vulnerable Growling Grass Frog. • Waterbird feeding and breeding habitat.
RIVER RED GUM FDU		
• Restore the health of River Red Gum FDU	• R1: >80% of River Red Gum FDU with a flooding regime that maximises healthy condition. • R2: Range of age classes exist for River Red Gums in at least 75% of surveyed areas. • R3: River Red Gum FDU: Plant Functional Groups 2-7 have >50% of total cover occupied by at least 2/3 of all species possible within these Plant Functional Groups. • R4: > 75% of surveyed trees with 'healthy' canopy condition - crown condition index score of 4 or greater. • R5: >50% of threatened flora species previously recorded observed. • R6: High threat exotic plants absent in >90% of total cover	• FFG Act listed River Red Gum Grassy Woodland ecological community. • 23 threatened flora species.
NATIVE BIRDS		
• Restore healthy wetland bird community, through improved access to food and habitat that promotes breeding and recruitment	• B1: Successful colonial waterbird breeding in at least 3 years in 10 (for a range of species – egrets, cormorants, herons). • B2: Successful waterfowl breeding in at least 7 years in 10. • B3: >50% of all waterbird species expected to occur observed over a ten-year period. • B4: >60% of the floodplain inundated for colonial waterbird foraging in 8 years in 10. • B5: Presence of water in swamps with emergent vegetation (e.g. Reed Bed Swamp, such as bullrush *Typha spp.*, reeds *Phragmites spp.* and sedges *Eleocharis spp.*) in at least 7 years out of 10. • B6: >50% of the wetland bird species of conservation significance recorded observed over a ten-year period.	• Bird species of conservation significance e.g. EPBC-listed Australasian Bittern • Waterbird feeding and breeding habitat, particularly colonial waterbird nesting sites.
NATIVE FISH		
• Enhance River Murray native fish populations by increasing access to productive floodplain outflows.	• F1: Commonly occurring large-bodied, channel specialist native fish species (Murray Cod and Golden Perch) occur every year in local River Murray surveys and include a range of age and size classes.	• Diverse fish community similar that recorded around Gunbower Forest expected. • EPBC-listed Murray Cod in the River Murray.

4.4 Interdependencies

Achievement of the ecological objectives for Guttrum and Benwell Forests is important in a regional sense, as they form part of a wider regional floodplain ecosystem with Campbells Island directly opposite in New South Wales, and the Gunbower-Koondrook-Perricoota Forest immediately upstream (Ecological Associates 2013). The Kerang Lakes Ramsar site is approximately 20km to the south-west. The cumulative benefits of maintaining a network of well connected, resilient and healthy wetlands is critical in addressing the decline of many threatened water-dependent species, such as the Australasian Bittern, that have lost substantial habitat across Australia. This section discusses the importance of Guttrum and Benwell Forests in this regional context for different types of fauna.

4.4.1 Waterbirds

Widely dispersed networks of wetlands are often needed to provide sufficient habitat for waterbirds. Different types of waterbirds require different types of wetlands to feed and breed and this habitat specialisation may require them to use wetlands over a large scale (Lau 2014). For example, the success of colonial waterbird breeding depends on access to foraging sites at a regional scale. Nesting birds are known to travel to wetlands within a 20 km radius of their nesting sites in search of food (Reid 2006 cited in MDBA 2012). Breeding waterbirds in Gunbower Forest have, anecdotally, been reported to move on a daily basis from the lower Gunbower forest to the adjacent Koondrook-Perricoota Forest for foraging (North Central CMA 2009). Management of Guttrum and Benwell Forests to meet the objectives for providing foraging and nesting habitat will enhance waterbird populations throughout the region and MDB.

4.4.2 Fish

Lateral connectivity between the river and wetlands is critical for fish populations as floodplains provide feeding and nursery zones, and diversity of habitat with heightened survival, feeding and reproduction opportunities (Junk et al. 1989). Small-bodied fish in particular exhibit high levels of lateral movement (Lyon et al. 2010) indicating the importance of habitat connectivity for these fish communities. Flood flows that drain from the forest floodplain are rich in food and nutrients lifted from the floodplain floor and provide an input of food sources to the River Murray that benefit riverine fish (Humphries et al. 1999). Connectivity between channel and floodplain habitat, and management of return flows from the floodplains to the River Murray will assist in achieving the objective to enhance River Murray native fish populations.

4.4.3 Reptiles and amphibians

Amphibians are opportunistic users of temporary wetlands, with the mobility to seek suitable habitats as wetlands fill and dry. Temporary waterbodies are often preferred habitat by amphibians because the seasonal drying precludes predators and the availability of food sources is high (Wassens et al. 2008). However, decreases in landscape connectivity through fragmentation and habitat loss have contributed to declines in amphibian assemblages (Lehtenin et al. 1999), highlighting the importance of maintaining river-floodplain connectivity for this type of fauna.

Reptiles such as the Common Long-necked Turtle are known to move in accordance with drought and flood cycles and associated availability of resources, and often move up to 5 km between wetlands (Roe et al. 2009). Management of Guttrum and Benwell Forests to meet the objectives for semi-permanent wetlands, as well as enhancing connectivity between the floodplain and channel habitats will ensure that suitable habitat is provided for these fauna.

4.5 Contribution to Basin Plan objectives

The Project will contribute towards the environmental objectives described in the Basin Plan as shown below.

Table 4-2: Link between Guttrum and Benwell Forests Environmental Works Project and Basin Plan objectives

Basin Plan overall environmental objectives*	Contribution of Guttrum and Benwell Forests Environmental Works Project to meet overall* and specific^ Basin Plan objectives
a) to protect and restore water-dependent ecosystems of the Murray-Darling Basin	• Guttrum and Benwell Forests are water-dependent ecosystems within the Basin that support species listed under CAMBA and JAMBA (e.g. Eastern Great Egret (*Ardea modesta*) – CAMBA/JAMBA and White-bellied sea-eagle (*Haliaeetus leucogaster*) – CAMBA). • Inundation of about 1200 ha resulting in high floodplain productivity across a range of aquatic habitats. Following recession of floodwater, the return flows from the floodplain to the River Murray will promote ecological dispersal. • Protection and enhancement of water-dependent ecosystems that support numerous listed threatened species and ecological communities. • Protection and enhancement of representative populations and communities of native biota.
b) to protect and restore the ecosystem functions of water-dependent ecosystems	• Provision of opportunities for lateral and longitudinal connectivity between the forest floodplain and the River Murray – with approximately 35% of water held in the forests returned to the river. • Provision of a range of diverse habitats for biota including semi-permanent wetlands and River Red Gum forests with flood-dependent understorey. • Meeting the flow requirements of these habitats, and timed to optimise ecosystem functions that maintain populations (e.g. recruitment and dispersal). • Provision of wetting and drying phases that enhance ecological community structure and stimulate species interactions and food webs.
c) to ensure that water – dependent ecosystems are resilient to climate change and other risks and threats	• Provision of a watering regime that sustains the ecological character of the forests. Without the project these forests cannot be watered by any means outside natural flood events – which are of an inadequate frequency and duration even under the proposed Basin Plan. • The proposed flooding regime will protect and enhance a diversity of habitat types across the forests, which will be critical to biota under a drying climate. • The flooding regime, including wetting and drying cycles and inundation intervals, will be tailored to meet the hydrological requirements of water-dependent values within the range of tolerance to maintain overall ecosystem resilience.

* From Chapter 5 of Basin Plan, ^ From Chapter 8 of Basin Plan

5 Anticipated ecological outcomes

5.1 Current condition

The Guttrum and Benwell Forests comprise considerable areas of floodplain forest and support rare and threatened species, and stands of large old trees (Bennetts 2014). The current overall condition of native vegetation within the forests is considered to be moderate to good, though the distribution of vegetation types has changed dramatically, and many individual ecological components of the forests show extensive signs of modification, as a result of a change in hydrology.

Condition assessments and mapping of the water regime classes/EVCs undertaken in November 2014 identified the current distribution and quality of vegetation communities. Figure 5-1 and Figure 5-2 show a comparison between the historical and current distribution of WRCs. The results demonstrate a considerable shift from the communities that would be expected under a more natural flooding regime. The most significant overall change is the terrestrialisation of water-dependent vegetation communities. River Red Gum FDU has been replaced with drier, flood-tolerant understorey, and semi-permanent wetlands are encroached by terrestrial species and River Red Gums.

Table 5-1: Changes from the original extent of water regime classes

Water regime class	Original extent (ha)	Current extent (ha)
Permanent wetlands	2.3	0.3
Semi-permanent wetlands	289	0
Seasonal wetlands	0	54
Red Gum with flood-dependent understorey	998	1208*
Red Gum with flood-tolerant understorey	616	667

*The current extent of Red Gum FDU has increased due to expansion into semi-permanent wetlands.

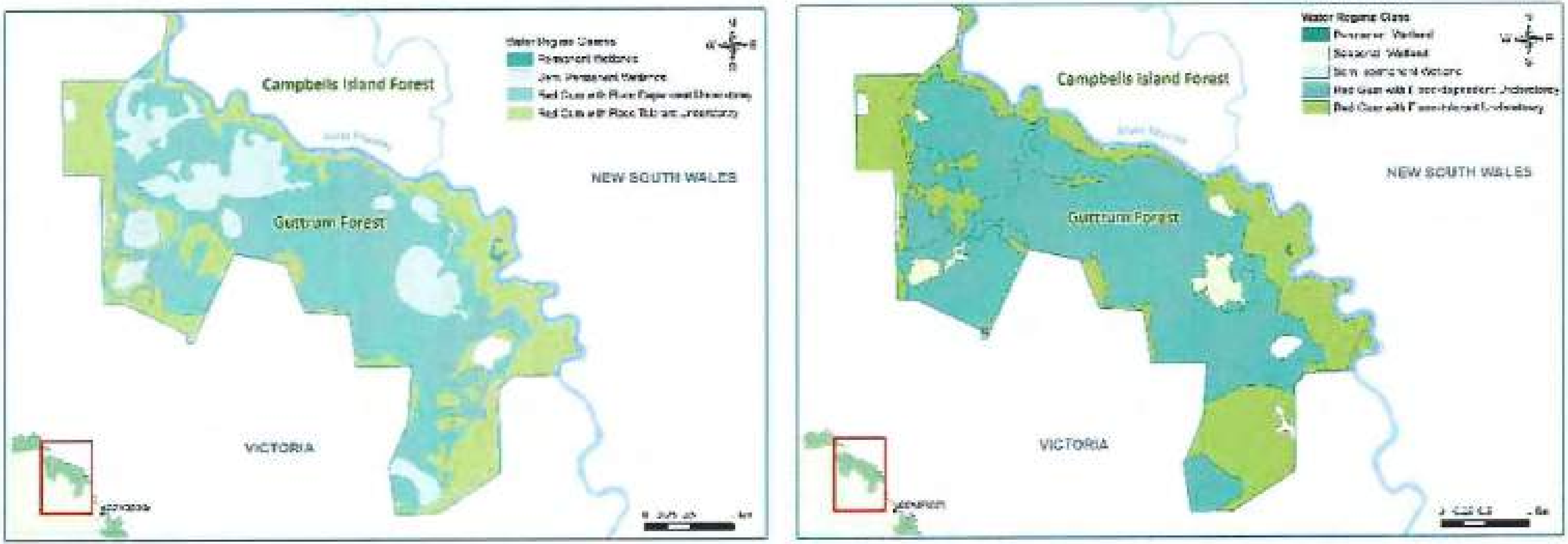


Figure 5-1. Guttrum Forest historical extent of WRCs (left) compared to current extent (right) (Ecological Associates 2013; Ecological Associates, unpublished 2014)

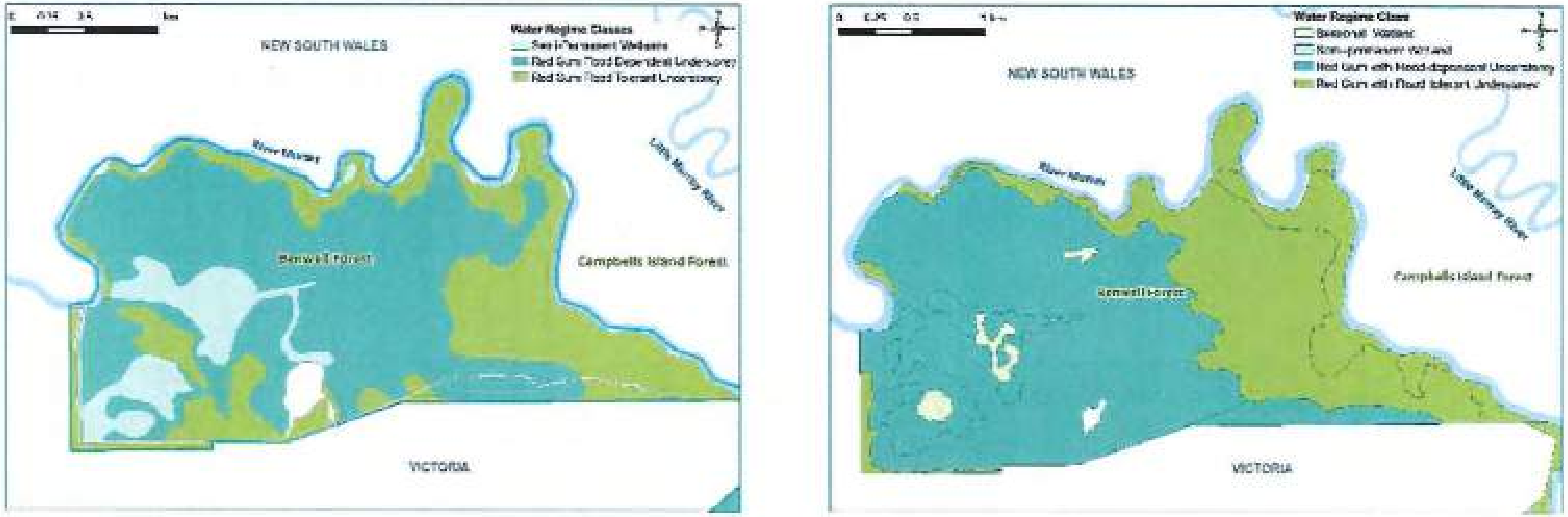


Figure 5-2. Benwell Forest historical extent of WRCs (left) compared to current extent (right) (Ecological Associates 2013)

5.1.1 Semi-permanent wetlands

Semi-permanent wetlands in the Guttrum and Benwell Forests, prior to regulation, would have received inundation on an annual basis for prolonged periods (Ecological Associates 2013). Under current conditions there is a significant reduction in flooding frequency and duration, which has been exacerbated by the recent Millennium Drought. This has resulted in considerably altered vegetation communities and habitat.

More specifically, the ecological integrity of semi-permanent wetlands in both Guttrum and Benwell Forests has been impacted by the extensive encroachment of terrestrial species, and River Red Gum saplings, and the colonisation of exotic species (SKM 2007; Bennetts 2014).

Across the majority of wetlands, the vegetation type is modified and dominated by species, both native and introduced, that are not typical of frequent inundation. The floristic composition indicates a recent history of prolonged dryness and an absence of flooding, which is required to promote a more diverse structure and presence of native species. The drier conditions provide a competitive advantage to the recruitment and spread of weed species (Biosis 2014b). Medic (*Medicago* spp.) is one of the most abundant weeds, forming mono-specific patches in the wetlands, and reducing biodiversity. The presence of this species is the result of extended dry periods (Bennetts 2014).

The drier flooding regime has provided optimal conditions for the germination and recruitment of River Red Gums, resulting in their encroachment into wetlands (Biosis 2014b). The total area of open wetland habitat and other flood-dependent vegetation has contracted over the last few decades – for example, the treeless extent of Reed Bed Swamp has decreased by 62% - indicating that this is a long-term effect of a change in hydrology (SKM 2007; Ecological Associates 2013; Bennetts 2014).

Different age classes of River Red Gum encroaching into Southwest Benwell Swamp (Photo G.Smith)

5.1.2 River Red Gum with flood-dependent understorey

Tree condition within Guttrum and Benwell Forests is considered moderate, though the drier vegetation types in higher elevations (i.e. further away from wetlands) are exhibiting signs of extensive drought stress (Biosis 2014b). Some mature canopy trees have died and many others are supporting epicormic growth (Bennetts 2014). Tree mortality is likely to be a response to the Millennium Drought in addition to long-term river regulation. Canopy trees in the south of Guttrum Forest are significantly impacted and are at risk of being lost if there are further extended dry conditions (Biosis 2014b). Trees in poor condition are known to contribute less to ecosystem functions and processes, reducing the habitat quality for dependent terrestrial fauna (Roberts and Marston 2011).

Both Guttrum and Benwell Forests contain many large, old trees that have persisted despite an altered flooding regime. These trees are of significant size and habitat value – the largest recorded had a DBH of 235cm (Biosis 2014b). The recent decade of drought, as previously noted, has had a significant impact on the health of the large old trees, with dieback and mortality evident in many (Bennetts 2014; Biosis 2014b). Also, generation of dense stands of saplings provides an additional stressor by competing for resources. Mature trees with healthy canopies generally out-compete saplings (Di Stefano 2001). However, a reduction in canopy cover and extent due to declining health, as well as gaps in the canopy introduced by forestry activities, has provided suitable conditions for the survival of large stands of River Red Gum saplings.

Water-stressed large old tree competing for resources in Benwell Forest (Photo: K.Bennetts)

Understories of the River Red Gum water regime classes are degraded from the 'benchmark' condition for these EVCs, due to the absence of some expected species (SKM 2007; Bennetts 2014; Biosis 2014b). This may be due to historical timber harvesting and selective grazing activities. There was limited recruitment and cover of shrub species observed and in some areas of the River Red Gum FDU, organic matter was considerably higher than the benchmark standards. Depth of organic matter can affect plant recruitment, and may explain the low cover of understorey species in many areas (Biosis 2014b). The recent re-mapping of WRCs within the forests has shown a considerable transformation of River Red Gum FDU to FTU, indicating that the former areas have received inadequate flooding to maintain their character.

While the forests generally contain representative floodplain species, several of them rare or threatened, there is a notable absence of perennial emergent macrophytes that would be expected throughout the semi-permanent wetlands and River Red Gums FDU. One example is the absence of Giant Rush (*Juncus ingens*) in Reed Bed Swamp, which historically was present but is now limited to a small stand in Little Reed Bed Swamp (Ecological Associates 2013). In Benwell Forest, perennial emergent macrophytes are limited to stands of Common Reed (*Phragmites australis)* in the understorey of the River Red Gum forest and are absent elsewhere (Ecological Associates 2013). The absence of these flora species and the food and habitat they provide is likely to have resulted in a decline in the presence of threatened native fauna, such as the Growling Grass Frog, which has been found in these forests previously (DSE 2010).

Guttrum Forest Giant Rush in Little Reed Bed Swamp (Photo M.Cooling)

5.1.3 Native birds

A number of rare and threatened water and woodland bird species have been recorded and observed in the Guttrum and Benwell Forests in the past decade. Recent surveys suggest that the forests are in a drier than usual state (Biosis 2014b), and more bird species than those recently observed are expected to utilise the forests. The shorter duration, reduced frequency and longer intervals between flooding have reduced opportunities for breeding events and foraging habitat (Ecological Associates 2013). Recent colonial waterbird nesting in Southwest Benwell Swamp is likely to have occurred in response to the 2010-11 floods, suggesting that when inundated, the wetland habitat still provides suitable conditions for breeding.

A decline in the condition of floodplain woodlands also affects the forests' ability to support a full assemblage of woodland birds (Fitzsimons et al. 2014). Their density and diversity is influenced by the health of the canopy trees, the productivity stimulated by flood events, and the availability of habitat elements such as hollows, fallen timber and the presence of understorey (McGinness et al. 2010). Both forests contain good quantities of fallen timber and numerous habitat trees, or stags (Biosis 2014a; 2014b).

5.1.4 Native fish

Native fish have not been surveyed in Guttrum or Benwell Forests, likely due to the semi-permanent or temporary nature of the wetlands. However, a number of threatened species are known to be present in the area, and would be expected to utilise the floodplain and semi-permanent habitat. The reduced frequency and duration of flood events has provided fewer opportunities for native fish to access the floodplain, and reduced the input of carbon and nutrients into the river channel (Ecological Associates 2013).

Colonial waterbirds nests in Southwest Benwell Swamp (Photo G. Smith)

5.2 Expected benefits of inundation

Environmental water delivery to the Guttrum and Benwell Forests will generate a range of environmental benefits in line with the vision for the Project: *To maintain and restore healthy floodplain communities across Guttrum and Benwell Forests, to ensure that indigenous plant and animal species and communities survive and flourish.*

5.2.1 Semi-permanent wetlands

A diverse array of processes and ecological components will benefit from reinstating a more natural flooding regime for the semi-permanent wetlands. These are summarised the in Table 5-2 with further detail provided below.

Table 5-2: Summary of anticipated ecological benefits in semi-permanent wetlands

Overarching ecological objective	Ecological benefits of inundation
Healthy semi-permanent wetlands	• Increased cover and diversity of wetland flora species, including rare and threatened species • Wetting and drying flux stimulates a productive food web • Halt encroachment of terrestrial species, including River Red Gums • Diversity of habitat for fauna, including rare and threatened fauna species.
Healthy wetland bird community in Guttrum and Benwell Forests through improved access to food and habitat that promotes breeding and recruitment.	• Shelter, nesting materials and nesting habitat for waterbirds • Suitable hydrological conditions and habitat provided for colonial nesting species • Foraging grounds for colonial nesting waterbirds and migratory wading birds • Suitable habitat for rare and threatened waterbird species • Abundance of food sources for waterbirds.

Providing a more natural flooding regime will restore the extent and distribution of wetland vegetation in Guttrum and Benwell Forests. The encroachment of terrestrial species and the dominance of introduced species will be addressed by providing more favourable conditions for native wetland species (Biosis 2014b). Monitoring programs in the nearby Gunbower Forest have shown this response following prolonged flooding (Bennetts & Jolly 2013). The proposed flooding regime will also limit further recruitment of River Red Gums by providing conditions that are unsuitable for seedling recruitment and growth (Ecological Associates 2013; Biosis 2014b). Existing stands of young River Red Gums can be difficult to control through inundation alone, as tolerance of flooded conditions increases with age. For example, seedlings 50-60cm tall can survive four to six months of shallow inundation (Dexter 1978), while mature River Red Gums have been known to tolerate up to 24 months (Bren 1987). In these situations complementary management actions may be required.

Vegetation communities and flora

Introducing a more natural flooding regime will ensure submerged and emergent wetland plants complete their life cycle (SKM 2007). Repeated wetting and drying phases will assist in maintaining the seed and rhizome banks, ensuring ongoing diversity and abundance of wetland flora throughout the forests (Bennetts & Jolly 2013; Leck & Brock 2000).

The maintenance of open water habitat in semi-permanent wetlands is critical to providing suitable conditions for rare and threatened water-dependent flora, such as the EPBC-listed River Swamp Wallaby Grass and FFG-listed Wavy Marshwort that are currently present in small numbers. Flora surveys to date have occurred only when the wetlands are dry, so a number of other threatened aquatic species observed in the region are likely to be present, such as the EPBC-listed Western Water-starwort (*Callitriche cyclocarpa*) (Biosis 2014b).

Native birds in semi-permanent wetlands

The reestablishment of reedy vegetation will provide habitat for the EPBC-listed Australasian Bittern, previously recorded at Reed Bed Swamp in Guttrum Forest (Disher 2000). Providing this habitat is critical for this endangered species, which has reduced significantly across its range (Silcocks et al. 2014). Promoting a diversity of wetland habitats will assist in achieving the objectives set for native birds. Marshy areas with semi-emergent vegetation are important to grebes and dabbling ducks; dense macrophyte beds are important for cryptic waterbirds such as the Nankeen Night Heron (*Nycticorax caledonicus*) and the Black-tailed Native Hen (*Gallinula ventralis*) (Ecological Associates 2013). Colonial nesting species often build stick nests in trees beside or overhanging water, so the River Red Gum fringes of the wetlands in Guttrum and Benwell Forests are critical. Evidence of this type of nesting has been seen in Southwest Benwell Swamp and has been observed in Reed Bed Swamp in Guttrum Forest. It is likely that given another large flooding event, the birds will take up these platforms again (Thomas, G personal communication, 16 November). The flooding regime proposed in Section 9 has the ability to maintain inundation of these fringe habitats for longer than four months, known to be preferential breeding habitat and conditions for a number of colonial nesting species historically recorded in Guttrum Forest e.g. Eastern Great Egret, Great Cormorant (Rogers & Ralph 2011). Following the 2010 natural flooding in Gunbower Forest, environmental water was delivered to maintain water levels of wetlands which resulted in successful breeding of thousands of waterbirds, including colonials (Stanislawski 2014).

The wetland productivity that is stimulated by flooding provides an abundance of prey items for waterbirds. Seasonal wetting and drying phases mineralise organic matter and support microbial and planktonic productivity soon after flooding commences. It is expected, as a result, that larger aquatic invertebrates, frogs and small fish species will proliferate during spring, providing a diversity of food sources that support birds of different feeding guilds such as fish-eaters, dabbling ducks, waders and grazing waterfowl that have previously been recorded within Guttrum and Benwell Forests (Ecological Associates 2013). The abundance of food sources is critical to successful breeding events, as it enables waterbirds to store fat for sustenance throughout their breeding seasons and stimulates reproductive processes (Rogers & Ralph 2011). At the tail-end of a flood, receding floodwater will provide foraging grounds for migratory wading birds that pick over invertebrates in drying mud (Ecological Associates 2013).

The wetlands and surrounding floodplain areas will provide foraging grounds, a source of nesting materials and suitable habitat for a diversity of waterfowl and colonial nesting species. Providing suitable conditions for breeding of colonial nesting species, particularly egrets, is also likely to provide suitable conditions for other waterfowl such as ducks, grebes, swamphens and herons (North Central CMA 2009). Egrets are amongst the last waterbirds to begin breeding, and may take as long as nine months to complete a breeding cycle; thus, it is thought that inundation of wetlands for this long would support breeding cycles of other waterbirds. If suitable feeding and breeding conditions for a range of waterbirds are provided, the diversity of species (including threatened species) and instances of successful waterbird breeding will increase.

Amphibians and reptiles

At present there is little cover of aquatic and semi-aquatic flora species within wetlands, with limited patchy stands of Giant Rush and other sedges, reeds and rushes. Benwell Forest retains a number of stands of Common Reed though these are distributed throughout the River Red Gum forest, rather than the wetlands. Restoring cover and diversity of emergent, submerged and floating vegetation will provide suitable complex habitat for the nationally threatened Growling Grass Frog, historically recorded in the forests and surrounding waterways (Ecological Associates 2013). This species prefers seasonally inundated water bodies that retain water for five to seven months (Rogers & Ralph 2011).

Providing more frequent inundation of wetlands within the forest will benefit turtles such as the Common Long-necked Turtle, which is known to take advantage of temporary water bodies. Turtle populations are substantially affected by drought (Chessman 2011), so frequent inundation of wetlands will provide important drought refuge.

5.2.2 River Red Gum with flood-dependent understorey

The anticipated benefits to the River Red Gum FDU is summarised in Table 5-3 with further detail provided below.

Table 5-3: Summary of anticipated ecological benefits in River Red Gum with flood-dependent understorey

Overarching ecological objective	Ecological benefits of inundation
Healthy River Red Gum FDU (temporary wetlands) across Guttrum and Benwell Forests.	• Increased cover and diversity of understorey flora species, including rare and threatened species • Halt and reverse encroachment of terrestrial flood-tolerant species • Improved tree and canopy condition, including in large old trees • Wetting and drying flux stimulates a productive floodplain food web • Diversity of habitat for fauna, including rare and threatened fauna species.
Healthy wetland bird community through improved access to food and habitat that promotes breeding and recruitment.	• Shelter, nesting materials and nesting habitat for waterbirds • Foraging grounds for colonial nesting waterbirds and migratory wading birds • Abundance of food sources for woodland birds.
Enhancement of River Murray native fish populations by increasing access to productive floodplain outflows.	• Availability of floodplain habitat for small- and large-bodied fish • An abundance of food sources (organic carbon, phytoplankton and zooplankton, nutrients) to support the riverine food web, including recruitment of large-bodied channel fish specialists.

Vegetation communities and flora

Providing a more natural frequency, duration and extent of flooding will restore the cover and distribution of River Red Gum FDU and reverse the encroachment of the drier River Red Gum FTU (SKM 2007). Monitoring programs in Gunbower Forest have shown a correlation between flooding and an increase in flood-dependent species richness and cover in this water regime class. Prior to flooding, terrestrial species were dominant as the dry conditions provided them with a competitive advantage. Conversely, the dominance of flood-dependent species two years after flooding suggests that once established, they were able to regain the competitive advantage (Bennetts & Jolly 2013). Given the similarities between this water regime class in Guttrum and Benwell Forests and Gunbower Forest, it is expected that providing an appropriate flooding regime will enable flood-dependent understorey species to re-establish (Biosis 2014b). This will have the benefits of boosting cover and diversity of flora species within plant functional groups, and halting and reversing encroachment of terrestrial species.

In addition, rare and threatened understorey species are expected to occur more frequently, such as the EPBC-listed Winged Peppercress (*Lepidium monoplocoides*) that is predicted to occur within Guttrum and Benwell Forests (Biosis 2014a). Monitoring in Gunbower Forest has shown that the greatest diversity of rare and threatened species occur after flooding (Bennetts & Jolly 2013). In contrast, the cover of introduced species appears to reduce after flooding, in part because of increased competition from native perennial species that emerge after flooding.

Restoring a more natural flooding regime to River Red Gum FDU will provide relief to currently water-stressed trees within the forests. The condition of tree canopy across the River Red Gum forests is likely to improve, which is especially important to mature trees that rely on soil water and groundwater recharge from flooding to maintain their health (Roberts & Marston 2011). Meeting the hydrological requirements of River Red Gums is also expected to reduce stress on mature trees by assisting them to out-compete surrounding dense stands of saplings, whilst providing unfavourable conditions for continued growth of the saplings and further recruitment (Bennetts 2014). This is especially important for maintaining the large old trees that provide valuable habitat to birds and terrestrial fauna (Biosis 2014b).

Native birds

The inundated River Red Gum floodplain is important to the success of waterbird breeding because it provides raised habitat for colonial waterbirds to nest in over water, and the productive floodplain provides an extended area for foraging (Ecological Associates 2013). The considerable area of inundation will provide foraging sites for colonial waterbirds breeding in the Reed Bed Swamp complex, Southwest Benwell swamp and other local areas. Nesting colonial waterbirds will travel to wetlands within a 20 km radius of their nesting sites to forage (Reid 2006 cited in MDBA 2012). For example, breeding waterbirds in Gunbower Forest have been, anecdotally, reported to move on a daily basis to the adjacent Koondrook-Perricoota forest for foraging and can be expected to use Guttrum and Benwell Forests also. This is also relevant to other wetlands to the south of Guttrum and Benwell, such as Lake Murphy where a number of threatened water birds were recently recorded including the Intermediate Egret (*Ardea intermedia*), another species historically recorded at Guttrum and Benwell.

The recession of floodwater in the understorey will provide a highly productive environment, which together with the increased diversity of understorey flora, will provide food and habitat for a number of floodplain and terrestrial fauna, e.g. seeds, fruit and forage for granivore birds such as finches (Ecological Associates 2013). Improving and maintaining the health of River Red Gums through the floodplain woodlands, and restoring the cover and diversity of understorey vegetation is likely to support a healthy assemblage of woodland bird species (Fitzsimons et al. 2014). In reciprocation, woodland birds such as nectivorous and insectivorous species play an important ecological role in maintaining tree health and regeneration.

Ecological processes and functions

When flooded, Guttrum and Benwell Forests will provide floodplain habitat for invertebrates, fish and other aquatic fauna. Flooding triggers the rapid decay and release of minerals and carbon from organic debris on the forest floor, supporting an aquatic food web of microbes, invertebrates and small fish. Native fish entering from the River Murray in natural floods and the irrigation channel in managed events will make use of the abundant floodplain food resources. The Project will be particularly valuable for small-bodied native fish by providing large areas of shallow flooded aquatic habitat. Water draining from the forest floodplain will be rich in dissolved organic carbon and convey woody debris, both of which are important for the riverine food web of the River Murray (Ecological Associates 2013). In addition, floodwater will contain high densities of phytoplankton and zooplankton that provide food of appropriate size and density for fish larvae (Mallen-Cooper et al. 2014). This is particularly important to promote recruitment of large-bodied channel fish specialists that spawn and recruit within the river channel (e.g. Murray Cod) (Mallen-Cooper et al. 2014).

5.3 Monitoring and Evaluation plans

The *Monitoring and Evaluation Plans for the Guttrum and Benwell Environmental Works Project* (MEP) outlines the proposed monitoring protocols for the overarching objectives relating to semi-permanent wetlands, River Red Gum Forest, native fish and native birds.

In each case there is a structured and practical monitoring protocol (based on that developed and used under The Living Murray program) to identify the condition of attributes that are reliable indicators of ecosystem health. The establishment of baseline data for each attribute is outlined in the MEP for Guttrum and Benwell Forests. Progress towards ecological objectives and targets can be identified over time. This in turn provides a reporting and adaptive management mechanism to give confidence to the North Central CMA, funding agencies, the Victorian Environmental Water Holder (VEWH) and regional communities that the investment in the watering regime is achieving its intended aims.

The MEP will be formalised once funding has been confirmed. Ongoing monitoring costs are outlined in Section 16.2.4. The final MEP for this supply measure will be informed by broader intergovernmental arrangements for Basin-wide monitoring and evaluation under the Basin Plan. This measure is expected to contribute to the achievement of outcomes under two key Chapters of the Plan, namely: (i) the delivery of ecological outcomes under Chapter 8; and (ii) under Chapter 10, meeting the relevant sustainable diversion limit/s (SDLs), which must be complied with under the state's relevant water resource plan/s (WRPs) from 1 July 2019.

Both Chapter 8 and Chapter 10 of the Basin Plan are captured under the Murray-Darling Basin Authority's (MDBA) own monitoring and evaluation framework. Once specific Basin Plan Chapters commence within a state, the state must report to the MDBA on relevant matters. This will include five-yearly reporting on the achievement of environmental outcomes at an asset scale in relation to Chapter 8, and annually reporting on WRP compliance in relation to Chapter 10.

The proponent is satisfied that its participation in the MDBA's reporting and evaluation framework will effectively allow for progress in relation to this supply measure to be monitored, and for success in meeting associated ecological objectives and targets to be assessed.

This approach closely aligns with agreed arrangements under the Basin Plan Implementation Agreement, where implementation tasks are to be as streamlined and cost-efficient as possible.

6 Potential adverse ecological impacts

6.1 Overview

A comprehensive environmental, social and economic risk assessment in line with AS/NZS ISO 31000:2009 has been completed by the North Central CMA for the Project. This assessed both the likelihood of an event occurring and the severity of the outcome if that event occurred, for the following main aspects of the Project:

- Implementation: project management and construction risks
- Operation of the measure: ecological, social and economic.

The methodology generated a risk matrix in line with the ISO standards, which helped prioritise mitigation strategies and measures. The Risk Assessment Methodology in Appendix 3 provides the detail (including the definitions of the various likelihood and consequence ratings used for the assessment) and the process for undertaking it. The Risk Register at Appendix 3 documents the full suite of risks.

The high priority adverse ecological impacts associated with operation of the Project (implementation of the recommended watering regime) are described in this section along with the associated risk mitigation and control mechanisms. Further information is provided in this chapter on lower priority risks that are 'of interest'. The potential adverse social and economic impacts are described in Section 10. The Project development and construction risks are discussed in Section 17.

The risk assessment process and outputs demonstrates that the potential risks are well understood, and that risk mitigation controls are available, and when implemented ensure residual risks are acceptable.

6.2 Priority ecological risks from operation

The risk register in Appendix 4 records the full range of potential adverse ecological impacts. Of these, the four highest priority threats (defined as those in the 'High' or 'Very High' risk categories) are discussed below. These are pest fish, fish stranding, Giant Rush colonisation, River Red Gum encroachment and blackwater. Table 6-1 presents the initial and residual risk ratings. Further explanation of the risks, the potential impacts and proposed mitigation is provided in the following sections.

Table 6-1: High priority adverse ecological impact risk assessment

Risks	Initial risk			Residual risk		
	Likelihood	Consequence	Rating	Likelihood	Consequence	Rating
Pest fish	Almost certain	Major	Very High	Likely	Moderate	High
Fish stranding	Likely	Moderate	High	Unlikely	Minor	Low
Giant Rush colonisation	Possible	Major	High	Possible	Moderate	Moderate
River Red Gum encroachment	Unlikely	Major	High	Unlikely	Minor	Low
Blackwater	Likely	Moderate	High	Unlikely	Moderate	Low

Note: Adverse ecological impacts allocated to the lower risk categories can be viewed in the risk register. The more high profile threats in lower risk categories are discussed in the *Ecological Risks and Mitigation Background Paper* developed for the project.

6.2.1 Pest fish species

There is a risk that the proposed delivery method for Guttrum and Benwell Forests will introduce pest fish, which increase the general abundance of these species, reduce ecological values and reduce the likelihood that ecological objectives will be achieved. A number of non-native fish species are expected to be present in the channels of the Torrumbarry Irrigation Area (TIA). Species found in the associated Gunbower Creek and lagoons, which may be present in the irrigation channels supplying the Guttrum and Benwell Forests include Common Carp, Goldfish, Tench, Gambusia, Oriental Weatherloach and Redfin Perch (PIRVic 2007; Rehwinkel & Sharpe 2009).

All non-native fish compete for resources and habitat with native fish. However, carp are potentially the most destructive. They are highly invasive and when present in high densities can impact on wetland plants, habitats, turbidity, and native fish (Koehn et al. 2000). Carp can dominate floodplain fish communities where the shallow warm waters provide ideal conditions for spawning and growth (Stuart & Jones 2006).

Flood events, natural or managed, are likely to promote the successful breeding and dispersal of carp, amongst other pest fish species. However, the floodplain system (including the semi-permanent wetlands) will dry out every year and so the risks from carp are temporary and short-lived. The initial risk rating for this threat was: Very High.

Screening of adult pest fish (particularly carp) is proposed for forest inlets to prevent adults from entering the floodplain, via the irrigation system. Young pest fish will have less impact on the aquatic vegetation and still-water habitats (although it is acknowledged they will compete with native fish during the inundation period).

The risk of aquatic habitat degradation in Guttrum and Benwell Forests by pest fish is substantially lowered if operations can occur with carp screens. Rotating screens (i.e. self-cleaning) will be considered for installation to minimise operational maintenance requirements (e.g. clearing of trapped weeds).

From an operational perspective, the system will dry each year as occurs naturally. This will provide control over the release of any pest fish from the wetland systems into the River Murray, and will prevent the establishment of adult populations within the forests. Although mitigation measures can be implemented it remains very difficult to control and manage carp in natural flooding events where there is uncontrolled connection of the floodplain and the River Murray. Therefore, the residual risk rating is: High.

6.2.2 Fish stranding

Small and large bodied native fish may move into the forest wetlands and floodplain during watering events and become stranded when water delivery ceases. Without operational management, there may be no cues for fish to leave the floodplain and they may become trapped in isolated pools. The initial risk rating for this threat was: High.

A suite of controls will be implemented to address this risk including:

- Coarse screens at the inlets from the TIA to prevent entry of large bodied fish into the forests.
- Watering will be sequenced to maximise cues and exit routes e.g.:
  - The initial watering of the forests will involve an inflow rate of up to 250ML/day to provide comprehensive inundation of the floodplain
  - Once inundation is achieved a much slower flow rate of up to 50ML/day will be retained to maintain the extent of inundation over the desired duration.
  - Exit flows will be phased with an initial high flow to send signals of the flood recession.

The effectiveness of these controls will be confirmed through routine monitoring. Recent evidence from Gunbower Forest suggests the above style of fish exit strategy is very successful with flow changes cueing native fish to leave the floodplain. For example, in a single day approximately 14,000 fish passed through the fish lock at the Hipwell Road Channel. This included 6000 carp gudgeons, 8000 Australian smelt, 16 carp, 1 bony herring, 1 Un-specked hardyhead (Chatfield, A 2014, personal communication, 11 October). The residual risk rating for this threat is: Low.

6.2.3 Giant Rush colonisation

Giant Rush (*Juncus ingens*) is an invasive native species with the potential to affect the habitat structure within wetlands. While the species is a natural component of floodplain wetland communities, it has the potential to form extensive mono-specific stands as a result of intermittent shallow flooding during summer and autumn (Ecological

Associates 2010). River regulation, specifically lack of or reduced winter flooding and high water levels in summer months, is believed to favour Giant Rush (Chesterfield et al. 1986; Leitch 1989). This occurred in the Barmah-Millewa system when conditions provided constant summer flows with a lack of flow peaks in the River Murray over a number of years. The high volumes of flood water in 2010 removed the majority of Giant Rush that was covering the Barmah Lake (Ward, K [Goulburn Broken CMA] 2014 personal communication, 16 October).

The risk of Giant Rush invasion in the Guttrum and Benwell Forests is relevant to all the semi-permanent wetlands, which will have shallow flooding over late spring and summer, particularly is bird breeding occurs a number of years in a row. The initial risk rating was: High.

Currently, Giant Rush is present in small stands within the wetlands. Maintaining a strong seasonal profile to the flooding regime, with peaks in spring and a recession over late spring and summer will reduce the risk of Giant Rush becoming an issue in the wetlands. However, regeneration of Giant Rush will need to be monitored regularly, in particular following any late spring-summer flooding for bird breeding, to determine if other controls are required (Ecological Associates 2010). Expansion of Giant Rush can be tracked and the flooding regime can be modified if required (i.e. to avoid summer inflows).

Once colonised in a wetland, opportunities for containing Giant Rush by habitat or environmental manipulations are few. Reducing adult stands by flooding regime manipulations (drying or drowning) is a long-term project that impacts the entire wetland, and would require sustained effort over several years to be successful. For new patches of Giant Rush, seedling mortality by submerging is probably the most effective control, but the opportunity window is brief (Roberts & Marston 2011). The residual risk rating is: Moderate.

6.2.4 River Red Gum encroachment

Ideal conditions for River Red Gum germination and establishment are provided during a spring-early summer drawdown on the floodplain i.e. damp soil and warm temperatures. It is common for wetlands to include scattered mature River Red Gums or small thickets of saplings (DSE 2003) that germinated under such conditions (Roberts & Marston 2000). However, extensive encroachment reduces the habitat diversity in wetlands. As trees invade they shade the understorey and lead to a decline in the cover and diversity of aquatic plant communities impacting on the availability of habitat for waterbirds, fish, frogs and other fauna.

Flooding regimes that include prolonged inundation, high temperatures over summer, and frost during winter, provide the best conditions for preventing River Red Gum establishment (Ecological Associates 2010). The shallow nature of the Guttrum and Benwell Forests' wetlands means that water depths of less than 1.5 m are common. Environmental watering through the Project has the potential to provide ideal conditions for River Red Gum growth and further exacerbate the existing encroachment issue (Ecological Associates 2013). The initial risk rating was: High.

Water can be managed to prevent the invasion of River Red Gum. Extending the drawdown period to late summer/early autumn in line with natural drawdown periods will be beneficial for deterring River Red Gum encroachment (North Central CMA 2014c). To kill the trees that have already encroached, hydrological management, such as longer wetland inundation events in the order of two years, will eventually kill the trees. However, shallow flooding over summer may increase other risks, particularly the spread of aquatic weeds, the growth of carp and the likelihood of blackwater events. Physically removing invading River Red Gum from wetlands is a more precise mitigation alternative, but labour intensive. However, this complementary action could be incorporated into the Forest Coupe Plan managed by DEPI. The residual risk rating is: Low.

6.2.5 Water quality and salinity risks downstream

A semi-quantitative assessment of the potential salinity impacts of environmental watering activities at the Guttrum and Benwell Forests was undertaken. The estimated salinity impact at Morgan under the operating scenarios was found to be negligible (<0.01 µS/cm EC) (Jacobs 2014).

Blackwater events have the potential to occur during watering of the Guttrum and Benwell Forests, though are likely to be localised (i.e. within the forests). Blackwater can have low levels of dissolved oxygen and may therefore cause stress to fish and other aquatic animals. However, blackwater is also a natural part of the floodplain and river system ecology. It replenishes carbon and increases productivity in the food web. Blackwater is most likely to occur in areas with high organic loads, little circulation and warm water. The risk of blackwater forming in Guttrum and Benwell Forests is relatively high. However, the risk of it causing ecological impacts is considered to be low.

During a watering event maintenance flows, recommended as part of the operating regime (see Section 9), will provide through-flows and help mitigate any water quality risks. At an inflow of 50 ML/day in Guttrum Forest, outflows to the River Murray are 24-33 ML/day during the August to November maintenance flow period. At inflows of 50 ML/day in Benwell Forest, outflows to the River Murray are 19-33 ML/day (DHI 2013) during the August to November period. These are very small outflows to the River Murray which is likely to have significant dilution flows and is unlikely to affect water quality in the river. In the unlikely scenario that River Murray flows are inadequate to safely dilute the blackwater, it can be retained on the floodplain.

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

It is expected that likely or potential downstream/cumulative impacts will become better understood as the full package of adjustment measures is modelled by the Murray-Darling Basin Authority and a final package is agreed to by Basin governments.

6.3 Other potential risks

6.3.1 Connectivity

The Project does not alter the connectivity between the forests and the River Murray under natural flood events e.g. the inlet and outlet regulators have been designed to retain the existing commence to flow thresholds and to pass natural flood outflows at the same rate as occurs currently.

Delivery of water from the irrigation system has a reduced level of connectivity than would otherwise be provided if River Murray inflows were being utilised. There will be less opportunity for native fish to access and use floodplain, than if a natural waterway was being utilised. However, alternative options were not feasible and through-flows and fish passage will ensure that connectivity with the River Murray is maintained, if not enhanced.

During a fully managed environmental watering event operation of the supply measure has been designed to mimic the natural through-flow nature of the forests. Inflows and outflows to the River Murray will occur at opposite ends of each site encouraging water movement across the majority of the floodplain.

Even with all outlets closed, any inflows received will continue to flow through the forests and return to the River Murray via the spillways (designed to enable large natural flood flows to pass through each forest).

7 Current hydrology and proposed changes

7.1 Hydrological context

Guttrum and Benwell Forests are situated in the central River Murray system (refer Figure 7-1), comprising the River Murray and its anabranches from Yarrawonga to the confluence with the Darling River at Wentworth. Major tributaries of the central Murray include the Goulburn, Campaspe and Loddon rivers in Victoria, and the Murrumbidgee and Wakool rivers in New South Wales.

Flows downstream of Torrumbarry Weir – the major regulating structure upstream of the Guttrum and Benwell Forests - are the cumulative result of flows from the River Murray from Barmah, Goulburn River entering upstream of Echuca, and flows from the Campaspe River entering at Echuca. At Barmah, river flows are limited by geomorphological features, with channel capacity restricted to approximately 10,000 ML/d through the Barmah Choke. As levels rise, the Edward River and Gulpa system carry a larger proportion of flows, bypassing Torrumbarry Weir and the forest floodplain systems downstream (CSIRO 2008; Atkins et al. 1991).

At Torrumbarry the Gunbower-Koondrook-Perricoota floodplain system is formed. While flood flows to Gunbower Forest in Victoria are returned to the River Murray at Koondrook via Gunbower Creek, flood flows entering Koondrook-Perricoota Forest on the right bank are diverted to the Wakool River in New South Wales. The loss of floodwater to the Wakool system greatly reduces river flows downstream of Koondrook, which are generally limited to 35,000 ML/d (MDBA 2014).

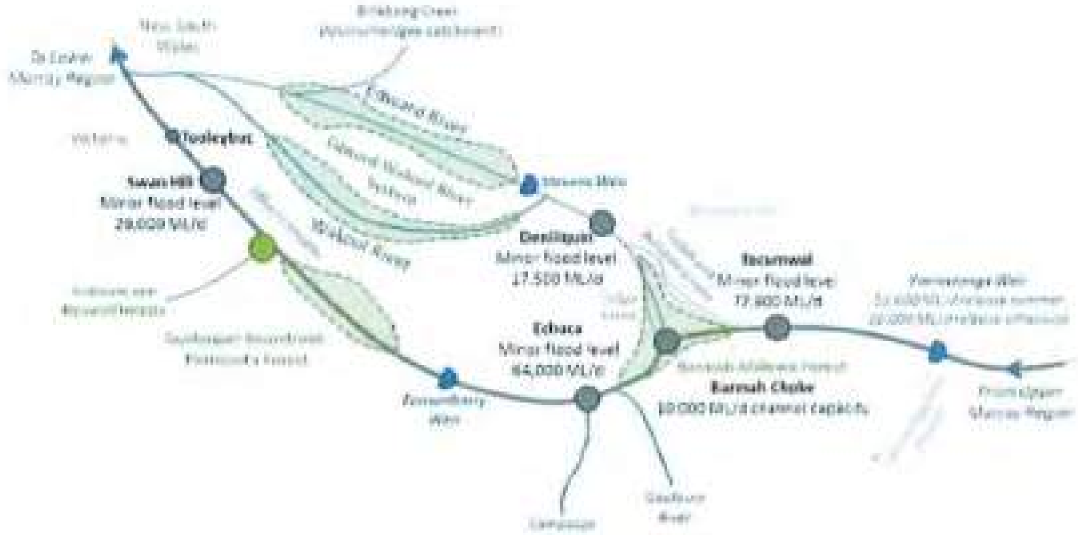


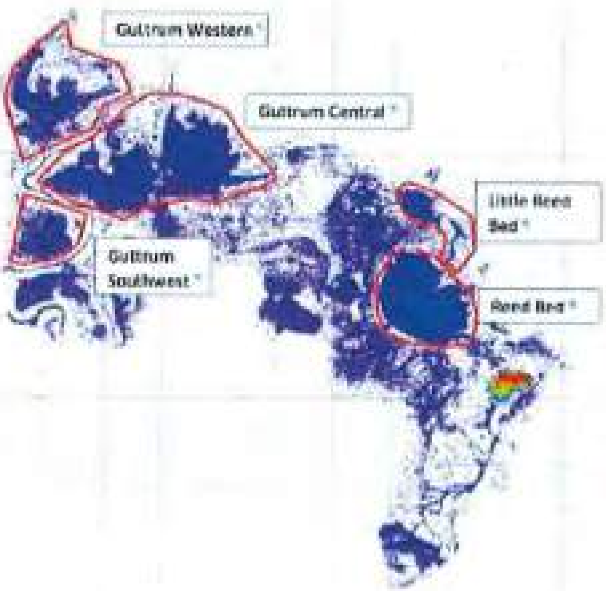
Figure 7-1: Schematic of the Mid-Murray region (Adapted from http://www.mdba.gov.au/what-we-do/water-planning/managing-constraints/constraints-overview/murray)

Downstream of Koondrook the Guttrum and Benwell Forests form part of the Campbells Island floodplain system, with Guttrum and Benwell Forests on the left bank, and Campbells Island on the right. Campbells Island is enclosed by the Little Murray River anabranch to the north, which at low flows departs from the River Murray opposite Guttrum Forest (8 km downstream of Koondrook), and rejoins the river at Murrabit, downstream of Benwell Forest. At high river levels, water in the Little River Murray is diverted north to the Wakool River via Little Merran Creek in New South Wales (Ecological Associates 2013). The Little Murray River is the last significant diversion from the River Murray channel, until the anabranches are reunited at Wakool near Boundary Bend.

Inundation of the Guttrum and Benwell Forests is determined by the height of the River Murray below the Barham gauge (at Koondrook), downstream of Torrumbarry Weir regulation, and the diversion of the Little River Murray. The characteristics of the forests' physical connection with the River Murray, via effluents and the river bank, influences the inundation resulting from particular flows within the river. The hydraulics of the individual floodplains then determines the final inundation pattern in response to these flows. Guttrum and Benwell Forests are generally basins, characterised by wetlands in the low-lying parts, surrounded by River Red Gum forest at slightly higher elevations. Each forest's connection to the River Murray and floodplain hydraulics are unique, and are described separately in the following sections.

7.2 Current Hydrology

7.2.1 Guttrum Forest



As the water level in the River Murray rises water enters Guttrum Forest through small floodplain creeks and flood runners. Water initially commences to flow through the north-western outlet (G5) when flows reach approximately 16,000 ML/d downstream of the Barham gauge. At this flow rate, water ponds in low-lying areas in the western end of the forest, between Smiths Drain, the southern levee and the outlet (Guttrum Western). Smiths Drain is a former irrigation channel that divides the Guttrum Swamp semi-permanent wetland (refer). First constructed in the 1880s to convey water from the river to irrigators south of the forest (GHD 2011), the drain comprises two parallel levees with the channel in between. The drain obstructs the movement of water at low flows (DHI 2013).

Below flows of 22,000 ML/d water ponds in the Guttrum Swamp complex (refer Figure 7-3) and there is no continuous flow through to the rest of the forest (DHI 2013). A break in the drain allows some movement of water at flows below 24,000 ML/d. At flows over 24,000 ML/d the bank is breached at several locations and then overtopped (Ecological Associates 2013).

Once river flows exceed 22,000 ML/d water will commence flowing through the G1, G2 and G3 inlets flowing into the Reed Bed Swamp semi-permanent wetland complex, and connecting through low-lying runners into Guttrum Swamp, from the east. The forest starts to operate as a throughflow system, with a steady flow of water from the east to west, as these major inlets engage (NRE 1997; SKM 2007; Ecological Associates 2013). Water spreads across the floodplain inundating large areas of the River Red Gum forest with flood-dependent understorey. At 26,000 ML/d flooding of this water regime class is mostly complete (DHI 2013; Ecological Associates 2013).

Once flows in the River Murray reach between 24,000 ML/d and 26,000 ML/d, water starts to spill over the lower banks just upstream of G5 (DHI 2013). The inflow volume from this overtopping is initially very small,with overbank flows becoming much more widespread when river flows are greater than 28,000 ML/d (DHI 2013).

At 28,000 ML/d water encroaches from the central floodplain floor into the River Red Gum flood-tolerant understory areas. This WRC is primarily located on elevated floodplain along the natural levee formed on the river bank. Flooding is largely complete at 34,000 ML/d as overbank flow becomes widespread (Ecological Associates 2013).

At lower river levels the low-lying riverbank inlet and outlet channels are the primary flow connections between the river and forest. Volumes entering the forests at various River Murray levels are presented in Table 7-1.

Table 7-1: Guttrum Forest – relationship between river flow and forest inflow (from DHI 2014a)

River flow (ML/d)*	Forest inflow (ML/d)	Depth (metres)	Area (Ha)	Volume (ML)
20,000	0	0.40	207	833
22,000	4	0.44	344	1498
24,000	67	0.44	683	3019
26,000	154	0.50	875	4417
28,000	418	0.59	994	5865
30,000	1112	0.65	1060	6935
34,000	1963	0.72	1111	8039

**Flows downstream of the Barham gauge.*

Note: These relationships are based on steady flow simulations, in which the forest inflows are balanced by outflows. The tables report the total inflow into the forest through inlets and overbank flows for each river flow.

At River Murray flows of 17,000 to 34,000 ML/d, depths generally increase from an average of 0.25 m to 0.72 m (DHI 2013). On the flood recession (Figure 7-2) water is retained primarily in low-lying wetland areas (DHI 2013; Ecological Associates 2013). Reed Bed Swamp retains water to a depth of more than 0.8 m over a large area, with Guttrum Swamp ponding water at 0.7 m. By retaining water, these areas are more likely to remain inundated between flood events. Modelling indicates that these semi-permanent wetlands will dry after four months from inflows ceasing (DHI 2013). Other areas of the forest retain water at shallower depths and will dry out more quickly (Ecological Associates 2013).

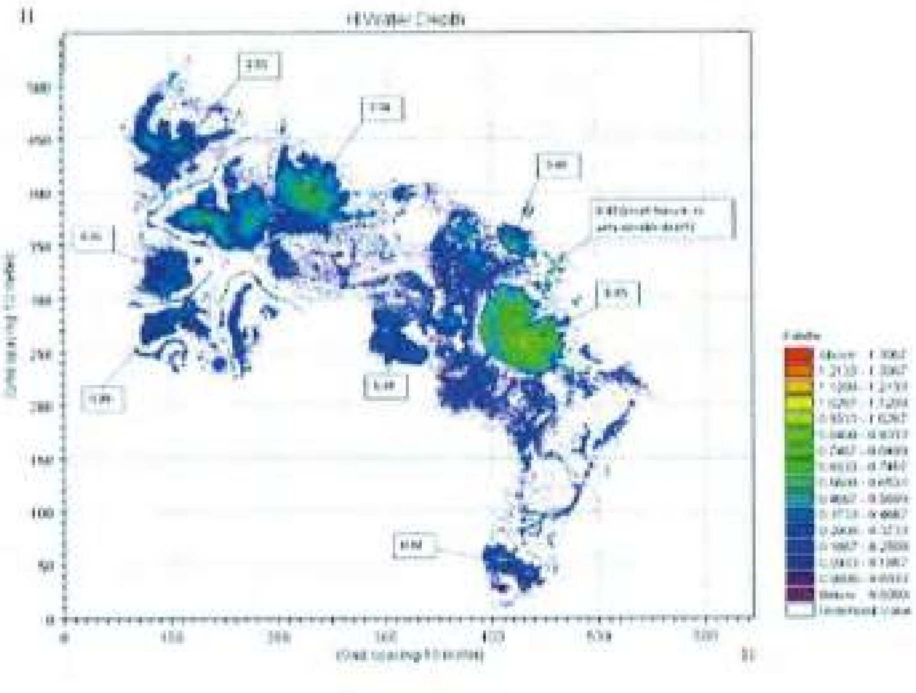
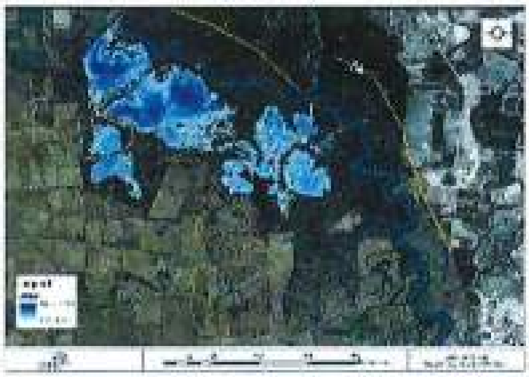


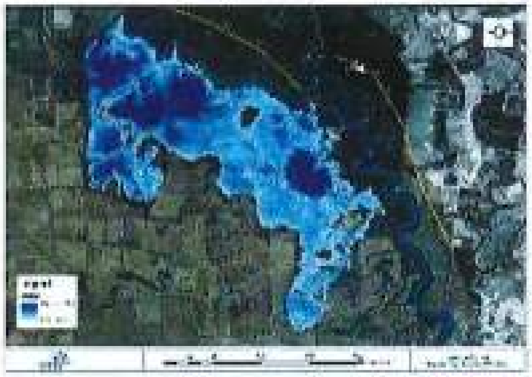
Figure 7-2: Retention of water in Guttrum Forest on the falling hydrograph

18,000 ML/d

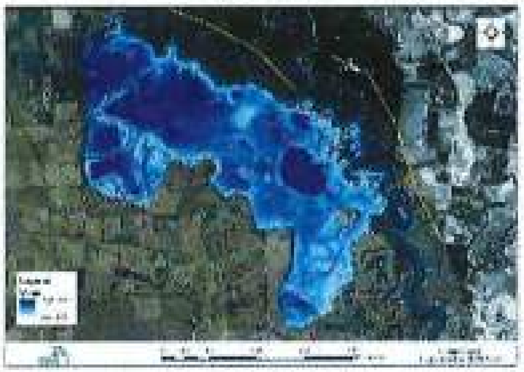
21,000 ML/d



23,000 ML/d



26,000 ML/d



32,000 ML/d

Figure 7-3: Distribution of water through Guttrum Forest on the rising River Murray hydrograph

7.2.2 Summary

The general distribution of water on the rising River Murray hydrograph in Guttrum Forest is summarised below.

Water inundation pattern for Guttrum Forest

18,000 ML/d: water first enters the forest, fills a wetland area between Millar Road and Smiths Drain Track then spreads along a small creek to the south and starts to fill Guttrum Swamp.

20,000 ML/d: Guttrum Swamp has largely filled and water spreads into the surrounding River Red Gum forest, along a narrow creek, crossing Sawpit Track and filling a third wetland basin to the south.

22,000 ML/d: flooding expands from these areas into the surrounding forest. Effluents in the upstream part of the forest also become active and introduce water to the Little Reed Bed wetland on the northern side of Reed Bed Swamp.

24,000 ML/d: forest inundation increases dramatically. The upstream effluents start to dominate forest inflows and through-flow commences. Water spills into Reed Bed Swamp. A shallow levee surrounding Reed Bed Swamp remains exposed.

28,000 ML/d: flooding expands to the constructed levees enclosing the forest on the southern and western boundaries. Most of the forest is inundated, except for the river levee.

30,000 ML/d: the river levee is mostly inundated in the lower part of the forest. A small, but very deep (>5 m) lagoon adjacent to the river is filled.

32,000 to 34,000 ML/d: water spreads further into the river levee in the upper part of the forest.

7.3 Benwell Forest

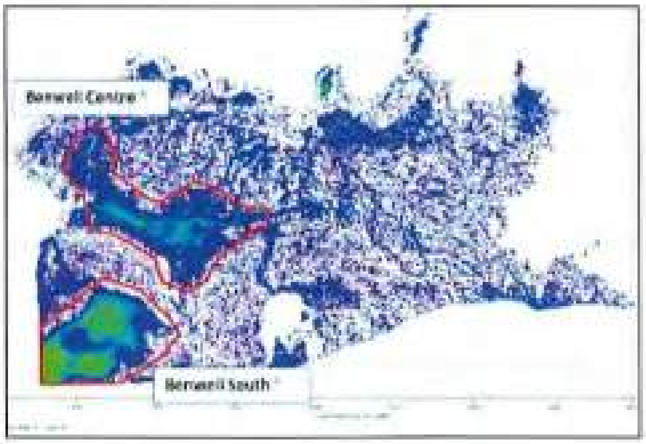


Figure 7-4. Semi-permanent wetlands in Benwell Forest

The majority of Benwell Forest lies in a single basin enclosed by the river levee to the north and east, and by constructed levees to the south and west. Benwell Swamp and Southwest Benwell Swamp represent the low lying areas within this basin (refer Figure 7-4). These semi-permanent wetlands are separated by a natural rise in the floodplain (Ecological Associates 2013).

Similar to Guttrum Forest, as the water level rises in the River Murray water enters Benwell Forest through small floodplain creeks and flood runners. Water initially commences to flow through the western outlet (B13) when flows reach approximately 15,000 ML/d. At this flow water ponds in low lying semi-permanent wetlands in the northwest of the forest (Benwell Centre Swamp).

The inlet B7 to the northeast starts to flow at approximately 16,000 ML/d. At these river levels inflows are low, and it takes a long time for the flow to connect east and west i.e. B7 to B13 and inundate the lower lying areas. This means filling times for lower flow rates are comparatively long. For smaller floods with continuous low inflows, the forest operates as a throughflow system with inflows from the east flowing through the forest, and returning to the River Murray through B13 (DHI 2013).

Other inlets in the east (B5) and north (B8) of the forest commence inflows at between 16,000 ML/d and 18,000 ML/d, and 18,000 ML/d and 20,000 ML/d respectively. Once flows reach these higher levels the forest fills considerably quicker (refer Figure 7-6). Flooding of the River Red Gum forest with flood-dependent understorey commences in Benwell Forest at flows above 18,000 ML/d and is mostly complete when flows reach 26,000 ML/d (DHI 2013, Ecological Associates 2013).

Benwell Forest has more variation in river bank levels than Guttrum Forest, with the eastern side having relatively high banks. No significant overbank flows are expected below river flows of around 30,000 ML/d. However there are a number of sections of low river bank along the northern side of the forest, particularly at B8, where overbank overflows commence at flows as low as 22,000 ML/d. There are also a number of other points along the northern bank between the B8 inlet channel and the B13 outlet that have thresholds of around 23,000 ML/d.

At lower river levels the low-lying riverbank inlet and outlet channels are the primary flow connections between the river and forest. Volumes entering the forests at various River Murray levels are presented in Table 7-2.

Table 7-2: Benwell Forest – river flow and forest inflow

River flow (ML/d)*	Forest inflow (ML/d)	Depth (metres)	Area (Ha)	Volume (ML)
15,000	0	0.3	0.5	1
16,000	4	0.18	59.7	108
18,000	61	0.24	229	555
20,000	200	0.34	318	1,080
22,000	489	0.44	447	1,967
24,000	896	0.53	495	2,635
26,000	2,723	0.60	516	3,124
28,000	4,497	0.66	533	3,504

**Flows downstream of the Barham gauge.*

Note: These relationships are based on steady flow simulations, in which the forest inflows are balanced by outflows. The tables report the total inflow into the forest through inlets and overbank flows for each river flow.

As flows reach 26,000 ML/d, flooding in the forest is widespread and deep (DHI 2013). Inundation depths range from 0.34 to 0.70 m with River Murray flows of 15,000 ML/d and 34,000 ML/d respectively. However Benwell Swamp South can pond water to a depth of 1.3 m. On the flood recession (Figure 7-5) water is retained primarily in low-lying wetland areas, in Benwell Swamp at an average depth of 0.5 m, and in Southwest Benwell Swamp at an average depth of 0.7 m (DHI 2013; Ecological Associates 2013). There is generally a slower and steadier decline in Benwell Forest compared to Guttrum Forest.

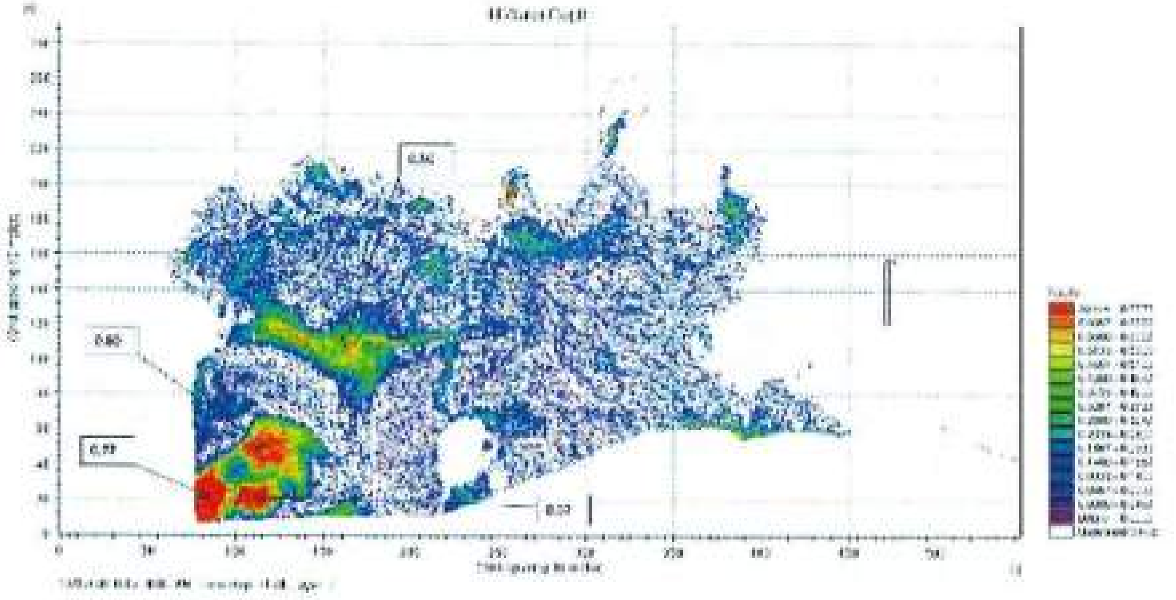
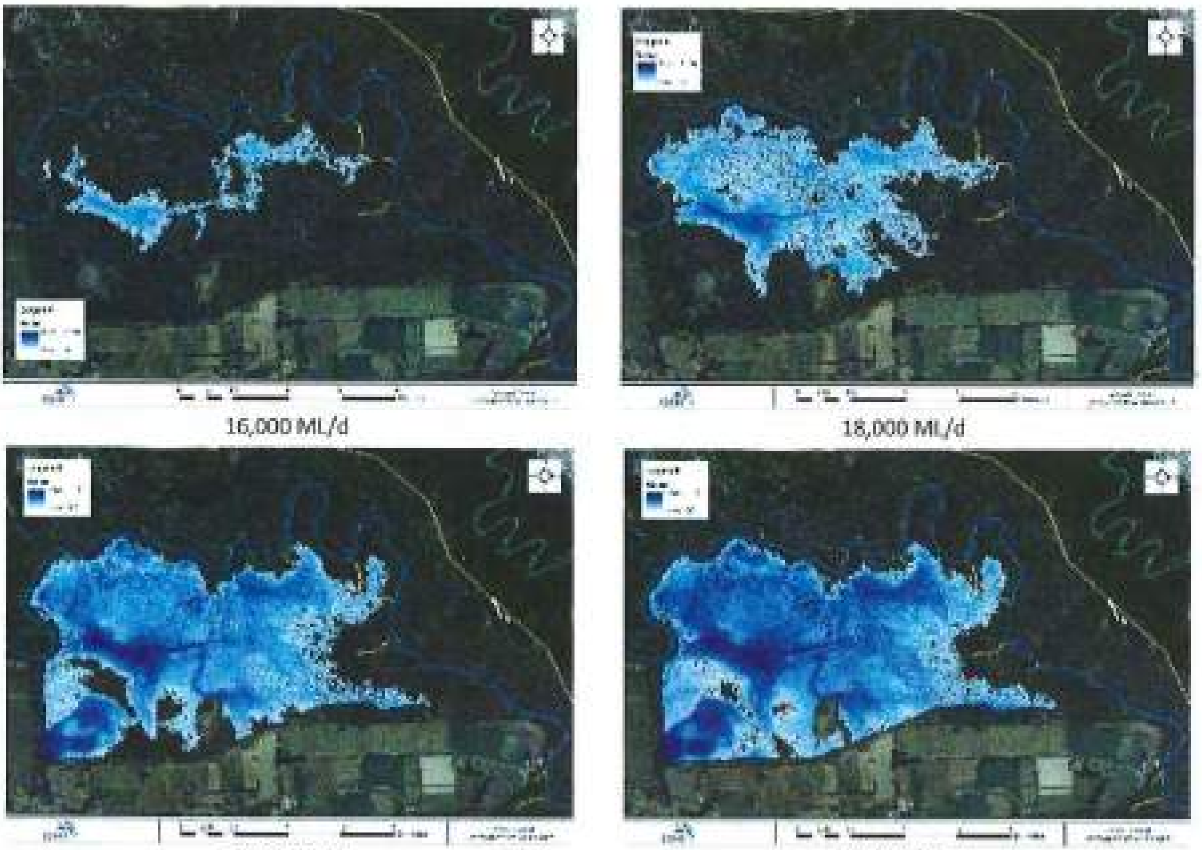


Figure 7-5: Retention of water in Benwell Forest on the falling hydrograph

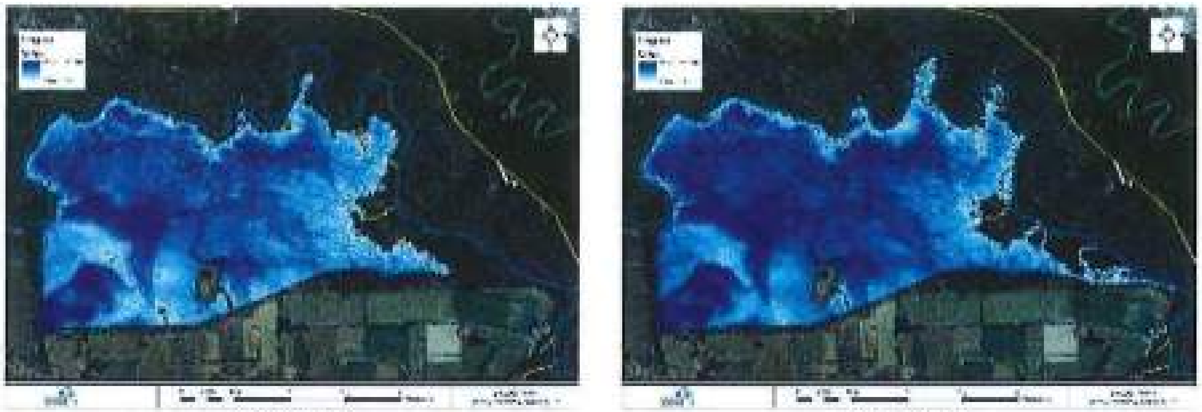


16,000 ML/d

18,000 ML/d

21,000 ML/d

23,000 ML/d



26,000 ML/d 32,000 ML/d

Figure 7-6: Distribution of water through Benwell Forest on the rising River Murray hydrograph

7.3.1 Summary

The general distribution of water on the rising River Murray hydrograph in Benwell Forest is summarised below (DHI 2013; Ecological Associates 2013).

Water inundation pattern for Benwell Forest

15,000 ML/d: water initially enters through the western outlet B13 with water ponding in adjacent low lying areas.

16,000 ML/d: water commences to flow from the upstream inlet B end of the forest. Water spreads by diffuse overland flow and accumulates in Benwell Swamp at the downstream end.

18,000 ML/d: water enters a second effluent upstream, creating widespread but shallow flooding in the River Red Gum forest. Benwell Swamp expands and spills to the river at a downstream effluent.

20,000 ML/d: a third upstream effluent becomes active consolidating the shallow flooding under the River Red Gum forest and around Benwell Swamp. Water reaches the levee at the southern boundary.

22,000 ML/d: floodwater overtops the natural rise that isolates the wetland area in the south-western corner of the forest. Flooding expands to the levees on the southern and western boundaries of the forest. The natural levee along the river bank narrows in the downstream part of the forest but remains broad further upstream.

26,000 ML/d: flooding in the forest is widespread and deep. Only a narrow strip of the river levee remains at the downstream half of the system. The wetland areas are connected by continuous flooding of the understorey.

28,000 ML/d: water is encroaching on the river bank from the River Murray at numerous locations.

30,000 ML/d: floodwater has spread into the meander loops. The river levee is very narrow and overbank flow occurs at several locations.

7.4 Flooding regimes of the forest

The sections above outline the relationship between flow rates in the River Murray and the inundation pattern within the Guttrum and Benwell Forest floodplains.

To understand the flooding regime of the forests - the frequency, duration and timing of inundation- the flow pattern within the River Murray at Barham was modelled. The mean daily flow series from Barham was evaluated from 1/7/1895 and 30/6/2009 (114 years) for historical 'natural' conditions, 'current' conditions (with TLM works), Basin Plan 2,750 GL and Basin Plan 2100 GL. Spells analyses were undertaken for flow thresholds between 15,000 ML/d and 35,000 ML/d at 2,000 ML/d intervals (Gippel 2014; Ecological Associates 2013).

This has provided the associated flooding regime for the forests pre and post river regulation, and the potential regime under implementation of the Basin Plan 2750. Table 7-3 and Figure 7-7 summarise the outputs.

Table 7-3: Spells analyses for downstream of Barham over 114 year modelled period (1895-2009). Barham is the nearest gauging station upstream of the forests.

Flow threshold exceeded (ML/day)	Natural conditions		Current conditions [1]		Basin Plan (2750 GL)	
	Mean frequency (events/100 yrs)	Mean duration (days)	Mean frequency (events/100 yrs)	Mean duration (days)	Mean frequency (events/100 yrs)	Mean duration (days)
>15,000	**100.9**	**173**	**80.7**	**75**	**92.1**	**114**
>17,000	98.2	162	73.7	74	91.2	97
>19,000	96.5	153	66.7	78	86.0	91
>21,000	94.7	139	61.4	69	75.4	86
>23,000	90.4	118	46.5	91	72.8	73
>25,000	**83.3**	**99**	**44.7**	**74**	**59.6**	**81**
>27,000	75.4	82	36.8	68	46.5	78
>29,000	62.3	76	35.1	32	39.5	64
>31,000	50.0	55	21.1	43	30.7	34
>33,000	**26.3**	**36**	**7.0**	**42**	**8.8**	**42**

Source: Gippel 2014: * Data is based on modelled monthly flows from MDBA – Monthly Simulation Model for flows between 1895 and 1999.

1. Benchmark conditions (with TLM). Note the DEPI BP971 and BP2100 scenarios produced inconclusive results

2. Duration is number of days per event that flow exceeded the threshold values shown in ML/day column

3. Frequency is the number of years, in the 100 years modelled, in which flows exceeded the threshold values shown in ML/day column.

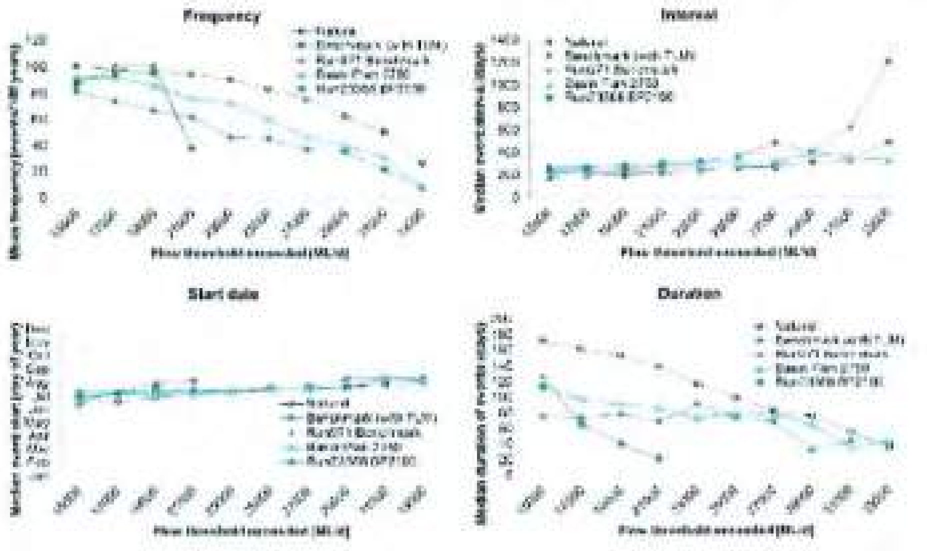


Figure 7-7: Outputs of spells analyses for River Murray at Barham (Gippel 2014)

7.4.1 Frequency

Flow into the forests commence when River Murray flows are greater than 16,000 ML/d for Guttrum Forest and 15,000 ML/d for Benwell Forest (DHI 2013; Ecological Associates 2013).

Under natural conditions there are near annual events at Barham for flows between 15,000 and 23,000 ML/d (Figure 7-8). At the mid- to high part of this range flows into the forests are significant. There is widespread inundation occurring across the River Red Gum FDU and semi-permanent wetlands in Benwell Forest, and water is starting to spread from low-lying areas and the Guttrum Swamp complex, into surrounding River Red Gum forest in Guttrum Forest.

Under current conditions the results indicate that as flow rates increase the frequency in which they occur tends to decline significantly, from natural. Events of 15,000 ML/d at Barham occur in 80% of years as opposed to annually. Flows in excess of 25,000 ML/d occur in less than 50% of years under current conditions, compared to 75% years under natural conditions. Events exceeding 31,000 ML/d occur in 20% of years, which is approximately half the natural frequency (Gippel 2014).

Under the Basin Plan 2750 GL scenario, there is an improvement in the frequency of events below 25,000 ML/d. However at 26,000 ML/d (to be mimicked by this Project for Guttrum Forest) the gap between natural and the Basin Plan 2750 GL scenario is three to four years in ten. Low to mid-range flows that provide water to the more flood-dependent vegetation are particularly critical. At these thresholds, the frequency of events falls short by 30%, with duration generally 1-2 months short of natural.

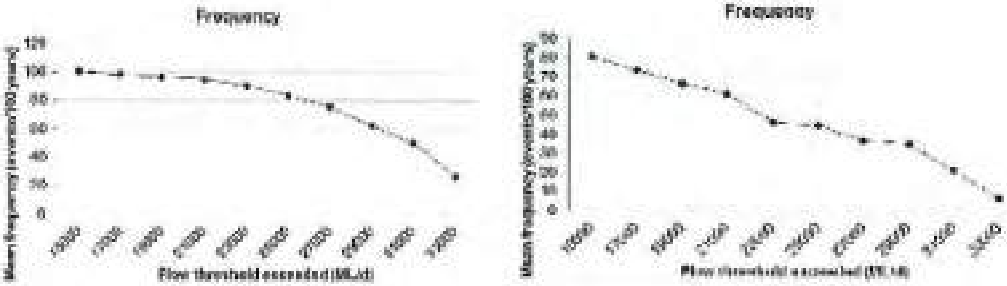


Figure 7-8: Frequency of River Murray flow events at Barham for natural and current conditions.

7.4.2 Duration

Under natural conditions the median duration of events in the River Murray declines as flows increase (Figure 7-9), from six months at 15,000 ML/d to one month at 33,000 ML/d (Gippel 2014; Ecological Associates 2013). The major flow events that cause widespread inundation of the forests would naturally have occurred for durations of between three and five months. Under current conditions there is a significant decline in the duration, particularly for lower flows. Flows of 15,000 ML/d are reduced from six months to two months. In addition, the variability in duration is greater under current conditions.

Comparing natural conditions to those under the proposed 2,750 GL Basin Plan, there is a marked improvement in duration at lower flow thresholds, but this effect reduces as flows increase. The deficit in duration of flow events at all thresholds remains. At low to mid-range flows that are particularly important for the semi-permanent wetlands, the duration is generally one to two months short of natural (Gippel 2014).

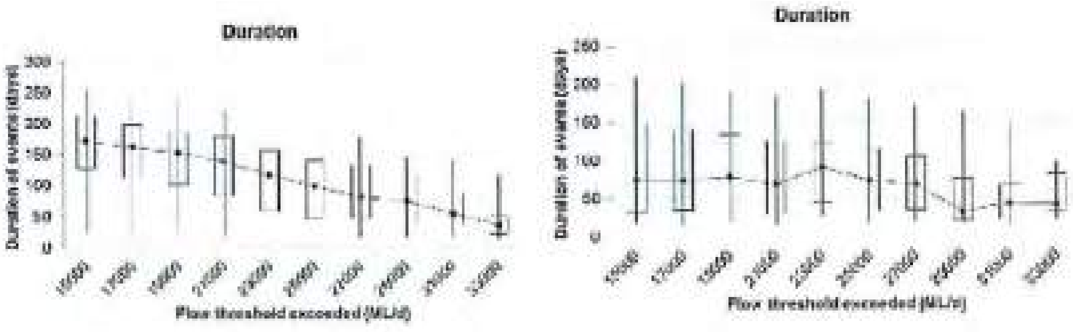


Figure 7-9: Duration of River Murray flow events at Barham for natural and current conditions.

7.4.3 Timing

The date at which flow events in the River Murray commence has low variability and is similar under all scenarios. Events generally start in June and July, with higher flow thresholds achieved later in the year, closer to August and September. Events start marginally later (about 4 weeks) under current and Basin Plan conditions, compared with natural (Ecological Associates 2013).

7.4.4 Event Interval

For flow events between 15,000 and 25,000 ML/d, under natural conditions, there is less than a year between events, highlighting the annual nature of these flows. The interval between events greater than 27,000 ML/d is greater and more variable, as these events are rarer.

Under current conditions the interval between events is similar, but more variable for events less than 23,000 ML/d, and longer and significantly more variable at higher flow thresholds.

The Basin Plan scenario reduces the variability and magnitude of intervals between events up to flows of 29,000 ML/d.

7.4.5 Summary

The analyses show that current conditions have substantially departed from what would have occurred naturally (Table 7-4):

The most significant reduction for ecosystem health is at the mid-flow threshold, where the frequency of watering for semi-permanent wetlands and River Red Gum FDU has reduced by more than one third (on average) from natural conditions and where the median duration has been reduced to three quarters of the natural length.

Table 7-4. Summary of flood deficit

Flows that inundate	Current frequency % of years	Duration of a typical current event (months)	Historic natural frequency % of years	Duration of a typical natural event (months)	Type of flow or interquartile range (ML/d)
Wetlands	75% of natural conditions	50% of natural conditions	Natural conditions	Natural conditions – up to 6	Low-flow
Wetlands and River Red Gum forests	50% of natural conditions	75% of natural conditions	Natural conditions	Natural conditions	Mid-flow
Total forest	50-75% of	40% of natural	Natural	Natural conditions	High-flow

	natural conditions	conditions	conditions		
Semi-permanent wetlands	61%	4	90%	3-6	21,000
River Red Gum FDU	37% of years	1-3	75% of years	2-5	27,000

7.5 Proposed Hydrology

7.5.1 Overview

Regulation of the River Murray has significantly altered the flooding regimes of the Guttrum and Benwell Forests, reducing the frequency and duration of inflows. The gap between current and natural flows for the ecologically important mid-range flows (at most relevant flow thresholds) is presented in Table 7-5.

The *Guttrum and Benwell Forests Environmental Works Project* aims to mimic a natural 26,000 ML/day flood event in the River Murray for Guttrum Forest, and a 24,000 ML/day flood event for Benwell Forest. It will do this by delivering environmental water to the forests; from new connections with the irrigation channel system (refer Section 9).

Table 7-5: Frequency and duration of events for 25,000ML/day flow events in the River Murray downstream of Barham

25,000ML/d River Murray flow	Natural conditions	Current conditions *	Basin Plan (2750GL)
Frequency (No. peaks per 100 yrs)	83	45	60
Mean duration (days)	99	74	81

The inundation extent and area resulting from watering of the forests, through this supply measure, are presented in Table 7-6. Further information on the area to be inundated, the types of habitat and vegetation watered, and the net volume of water used at each site, accounting for return flows to the River Murray is described further below for each forest. A description of the hydraulic models developed to inform the Project and the associated calibration/validation results, and assumptions, is provided in Appendix 5. Section 9 provides further detail on the range of scenarios in which watering of the forests will occur.

Table 7-6: Guttrum and Benwell Forest areas to be watered

	Guttrum Forest			Benwell Forest			Totals		
Water regime Class	Area (ha)	Area flooded (ha)	%	Area (ha)	Area flooded (ha)	%	Total area (ha)	Total area flooded (ha)	Total % WRC
Permanent Wetlands	2	0	-	-	-	-	2	-	-
Semi-permanent Wetlands	224	222	99	65	64	98	289	285	99
River Red Gum FDU	642	481	75	356	336	94	998	818	82
River Red Gum FTU	391	16	4	225	81	36	616	96	16
Total area	1269	719		660	481		1905	1199	

The Project will meet the watering requirements of the majority of semi-permanent wetlands (99%) and River Red Gum FDU (82%) in the Guttrum and Benwell Forests. These water regime classes have the greatest deficit in their flooding regime. Sixteen percent of the River Red Gum FTU will be inundated; however the water requirements of this water regime class are largely met by current conditions.

7.6 Guttrum Forest

The proposal for Guttrum Forest is to mimic the inundation extent of flows in the River Murray of up to, and including, 26,000 ML/d. In addition, the proposed flooding regime will restore a more natural frequency, duration and timing of flood events that meets the hydrological requirements of flora and fauna within the forests. Flow events of 26,000 ML/d would have occurred approximately 80 in 100 years for 90 days prior to river regulation, and now occur about 41 in 100 years for 70 days (median duration) (Gippel 2014). Events of this magnitude would have resulted in the inundation of all semi-permanent wetlands and most of the River Red Gum FDU in the forest (Ecological Associates 2013).

Inflows will be delivered via the No. 4 irrigation supply channel into the southeast and southwest corners of the forest (see section 11.3). Flows will be delivered at up to 250 ML/d and continued for approximately 11 days to achieve an inundation extent equivalent to that of a 26,000 ML/d River Murray flow (Figure 7-10). Once the maximum desired extent is achieved, the G5 outlet will be opened and maintenance flows provided to maintain the area for the required duration. Outflows would occur through the G5 outlet and water would drain from the forest floodplain to the River Murray as occurs naturally.

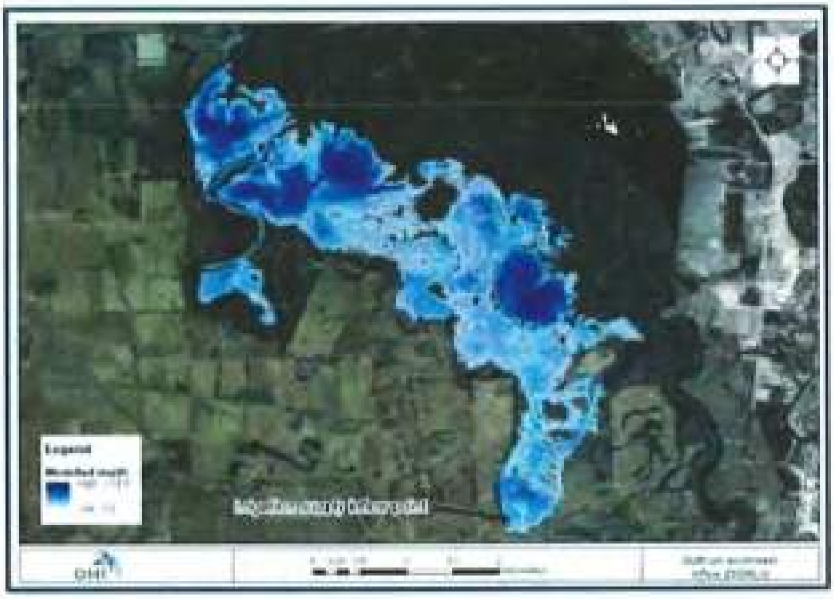


Figure 7-10: Guttrum Forest modelled inundation extent – 250ML/d inflow at southeast corner

Under this operation 99% of the area of semi-permanent wetlands will be inundated and 75% of the River Red Gum FDU (Table 7-6). A small percentage of River Red Gum FTU will be inundated, but the requirements of this water regime class are met through natural flows under current conditions.

7.7 Benwell Forest

The proposal for Benwell Forest is to mimic the inundation extent, frequency, duration and timing resulting from flows in the River Murray of up to, and including, 24,000 ML/d (Figure 7-11). Flow events of 24,000 ML/d would have occurred approximately 87 in 100 years for 109 days (median duration) prior to river regulation, and now occur about 45 times per 100 years for 83 days (median duration) (Ecological Associates 2013). Flows of this magnitude result in the inundation of all the semi-permanent wetlands and the majority of the River Red Gum FDU in Guttrum Forest.

Flows will be delivered at up to 250ML/d and continued for approximately 14 days to achieve an inundation extent equivalent to that of a 24,000ML/d River Murray flow

Flows of up to 250ML/d will be delivered for up to 14 days via a new irrigation supply channel in the southwest corner of the forest. The southwest inlet will deliver water directly into Southwest Benwell Swamp where it will flow north into Benwell Swamp North.

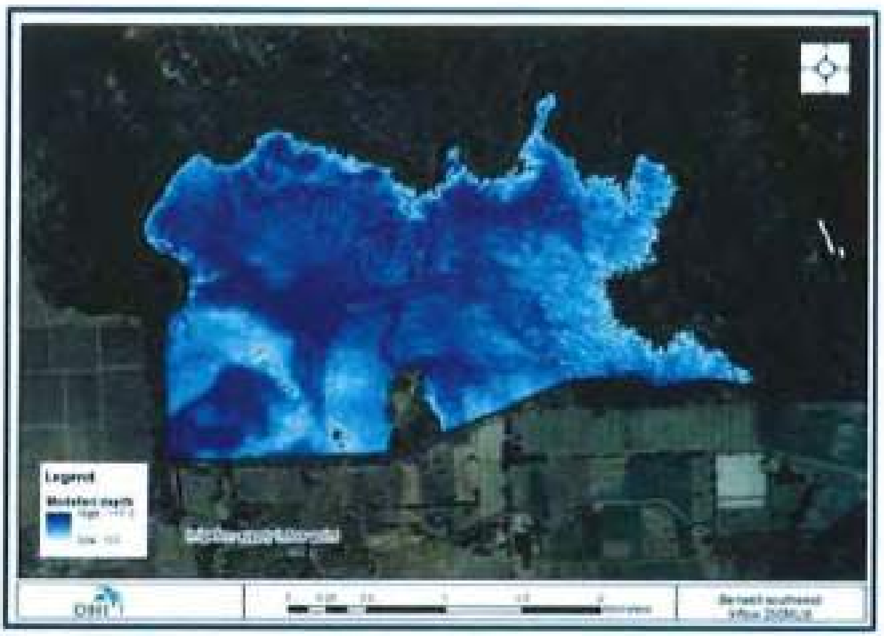


Figure 7-11: Benwell Forest modelled inundation extent – 250ML/d inflow at southwest corner

Under this operation 98% of the areas of the semi-permanent wetlands will be inundated and 94% of the River Red Gum FDU (Table 7-6). A small percentage of River Red Gum FTU will be inundated, but the requirements of this water regime class are met through natural flows under current conditions.

7.8 Water use

Return flows to the River Murray will occur under the forest floodplain watering scenarios (Section 9) in each forest. Return flows will not occur under fully managed environmental water delivery events to the semi-permanent wetlands, as environmental water will be retained within the wetland systems before gradually infiltrating and evaporating.

A watering event will occur in three phases:

- Filling phase – water is introduced into the forest until the intended inundation extent is achieved, with no outflows;
- Maintenance phase – inflows continue at lower rates to maintain the inundation duration and through-flow, with some outflows;
- Drawdown phase – water is released back to the River Murray from the floodplain.

Outflows during the maintenance and drawdown periods will range from 19-33 ML/d for both sites during these months (DHI 2013).

Taking into account the inflows under each operating scenario and the return flows to the River Murray, the estimated net water use in terms of the volume of environmental water retained on the floodplain has been determined (

Table 7-7).

Table 7-7: Estimated water use under the proposed operating scenarios

Scenario	Inflow volume (ML)	Return flow to River (ML)	Net volume used (ML)
Guttrum Forest			
Forest floodplain watering	8,250	3,079	5,171
Semi-permanent wetland watering - eastern wetlands	1,395	0	1,395
Semi-permanent wetland watering – western wetlands	3,820	0	3,820
Benwell Forest			
Forest floodplain watering	9,250	2,990	6,260
Semi-permanent wetland watering	1,800	0	1,800

Note: these volumes do not account for ramp up to peak flows, ramp down at the end of a watering event or contingency water used to maintain water levels in the event of waterbird breeding.

8 Environmental Water Requirements

8.1 Water requirements

The environmental water requirements for Guttrum and Benwell Forests have been determined according to modelled natural conditions and referenced with the hydrological requirements of the ecological values present.

The core ecological objectives for the Guttrum and Benwell Forests (Section 4.3) are for:

- **Semi-permanent wetlands:** Restore the health of semi-permanent wetlands
- **River Red Gum:** Restore the health of River Red Gum forests with flood dependent understorey
- **Waterbirds:** Restore a healthy wetland bird community across Guttrum and Benwell Forests through improved access to food and habitat that promotes breeding and recruitment
- **Native fish:** Enhance River Murray native fish populations by increasing access to productive floodplain return flows.

The indicative hydrological requirements for each ecological component described through the objectives are shown in Table 8-1.

The justification for this flooding regime is based on a substantial (scientific based) literature review as well as input by expert ecologists. Details of the scientific evidence supporting the environmental water requirements outlined below can be found in *Ecological Objectives and Hydrological Requirements Justification Papers* for Guttrum Forest and Benwell Forest (North Central CMA 2014a; 2014b).

8.2 Hydrological gaps to be addressed

Modelling suggests the hydrological requirements outlined in Table 8-1 will not be met under the Basin Plan 2,750 GL conditions (BP2750 April 2013 daily flow time series) (Gippel 2014). Table 8-2 shows where these gaps are expected to occur. This information has guided the operating regime for the supply measure (discussed in the next section), so that the hydrological deficits are addressed and the ecological objectives can be realised.

Table 8-1: Indicative hydrological requirements to achieve the Guttrum and Benwell Forests ecological objectives (North Central CMA 2014a and 2014b)

logical objective		Hydrological Objectives											Relevant water regime class (*equivalent River Murray flow threshold*)
		Recommended number of events in 10 years			Tolerable interval between events once wetland is dry (months)			Duration of ponding (months)			Preferred timing of inflows	Depth (m)	
		Min	Opt	Max	Min	Opt	Max	Min	Opt	Max			
store the health of semi-permanent tlands		6	9	10	1	6	36	3	6	8	Winter/ spring	Often <0.5 m. At Full Supply Level Guttrum Swamp is >0.7 m and Reed Bed Swamp is 0.85 m. The general depth of Benwell Swamp is 0.5 m and 0.7 m in Southwest Benwell Swamp.	Semi-permanent wetlands *23,000 ML/day Guttrum* *21,000 ML/day Benwell*
store healthy tland bird nmunity, through proved access to d and habitat t promotes eding and ruitment	Egrets	3	4	5	12	18	24	10	12	12	Late winter/ spring/ early summer	Not critical but maintain depth during breeding and provide gradual changes	River Red Gum forests (including semi-permanent wetlands) *26,000 ML/day Guttrum* *23,000 ML/day Benwell*
	General waterfowl (not colonial nesting species)	3	5	10	12	18	24	4	6	12	Late winter/ spring/ early summer	Maximise area up to 0.3 m deep. Need to fluctuate depth over time to promote wetland productivity.	Semi-permanent wetlands *23,000 ML/day Guttrum* *21,000 ML/day Benwell*
store the health of River Red Gum od-dependent Understorey		6	7	8	-	-	36	4	4	7	Winter/ spring	Not critical for adult River Red Gums. Varies for understorey. Some understorey sp. prefer shallow depths <.1 m during active growth but can tolerate deeper immersion for short periods.	River Red Gum forests *26,000 ML/day Guttrum* *23,000 ML/day Benwell*
ance River Murray native fish oulations by increasing access to ductive floodplain outflows.		6	7	8	-	-	36	4	4	7	Spring/ summer outflows to river after temp. and flow cued spawning occurs in channel.	Sharp drop in water level required to provide a fish exit cue in late spring/summer for any fish that have entered the floodplain. Hypothesis: 0.3 m over 48 hrs. This will also promote organic matter transport.	River Red Gum forests *26,000 ML/day Guttrum* *23,000 ML/day Benwell*

Table 8-2: Hydrological gaps in achieving the project's ecological objectives under the Basin Plan

Equivalent River Murray flow threshold	Flooding regime parameter	Optimum for floodplain habitat	Current conditions	Basin Plan (2750 GL)	Deficit to be addressed by project (v Basin Plan)
21,000 ML/day	Frequency (mean)	9 in 10 years	6 in 10 years	7.5 in 10 years	1.5 in 10 years
	Duration (median)	186 days	69 days	86 days	100 days
	Timing (month of median event start date)	Winter/spring	July	August	-
23,000 ML/day	Frequency (mean)	9 in 10 years	4.5 in 10 years	7 in 10 years	2 in 10 years
	Duration (median)	186 days	91	73 days	113 days
	Timing (month of median event start date)	Winter/spring	July	July	-
26,000 ML/day	Frequency (mean)	8 in 10 years	4 in 10 years	5 in 10 years	3 in 10 years
	Duration (median)	124 days	71 days	80 days	44 days
	Timing (month of median event start date)	Winter/spring	July	July	-

Source: Gippel (2014) – based on BP2750 April 2013 daily flow time series.

Note 1: the Guttrum Forest and Benwell Forest analysis use the same mean daily flow series data from Barham as this is the only nearby gauging station.

Note 2: the duration deficit in Table 2 does not match that proposed for the operating regime, as the operating regime also considers the duration of ponding in various locations on the floodplain.

9 Operating Regime

9.1 Overview

The Project proposes to reinstate a more natural flooding regime for Guttrum and Benwell Forests to support and enhance the sites' significant environmental values. This will be achieved by constructing infrastructure to enable the delivery of water, under a range of scenarios, from the Torrumbarry Irrigation Area into the forests. The water will be used to meet the current deficit in the flooding regime of the forests, and component water regime classes. In summary the Project will:

- Increase the frequency of inundation by watering in years when there are no natural events, filling the floodplains from a dry state
- Increase the extent and duration of inundation by complementing flooding from natural events
- Meet the specific watering requirements of the priority ecological communities/water regime classes.

This section outlines the proposed operating scenarios, designed to meet the hydrological requirements of the ecological objectives, and the role of operating infrastructure in implementation of the different scenarios.

9.2 Operating scenarios

Three operating scenarios have been identified for water delivery to the Guttrum and Benwell Forests:

- **River Red Gum watering** – broader floodplain (River Red Gum FDU and semi-permanent wetlands).
- **Semi-permanent wetland watering** – targeted water delivery to wetlands only.
- **Hybrid events** – topping up natural flow events for River Red Gum and semi-permanent wetland watering.

Hybrid events aim to 'piggy back' on natural inflows from the River Murray, by capturing those inflows and increasing the extent and duration of flooding. The use and extent of a hybrid scenario will vary depending on the natural inflow event and the opportunity available to maximise environmental outcomes.

Table 9-1: Overview of scenarios and their ability to meet the flooding regime requirements of the water regime classes.

SCENARIO	River Red Gum watering			Semi-permanent wetland watering			Hybrid watering		
Water regime class	Frequency	Duration	Timing	Frequency	Duration	Timing	Frequency	Duration	Timing
River Red Gum FDU	✓	✓	✓	-	-	-	×	✓	×
Semi-Permanent Wetlands	✓	✓	✓	✓	✓	✓	×	✓	×

9.3 River Red Gum watering

The River Red Gum watering scenario will water the forest floodplain from dry to increase the frequency of flooding events for the River Red Gum FDU and semi-permanent wetlands. The flooding will replicate a 26,000 ML/day natural event in Guttrum Forest and a 24,000 ML/day event in Benwell Forest, which would have occurred on average 8 years in 10 for between three to five months (DHI 2013). Operation of this scenario will address the hydrological deficit in frequency for the River Red Gum FDU (under current conditions approximately 4 in 10, under Basin Plan 2750 GL approximately 3 in 10).

The presence of climatic cues, availability of environmental water and the interval between the last floodplain watering will be important considerations prior to initiating a watering event.

9.3.1 Guttrum Forest

Water will be delivered to the forest via the No. 4 irrigation supply channel using the southeast corner inlet (DHI 2013). Delivery will continue until the level at the forest outlet G5 reaches 75.6 mAHD, to achieve the maximum inundation extent (727 ha, Figure 9-2) (Refer to Section 11.3 for further detail on the infrastructure and its role in operation). At this level, there are no return flows to the River Murray via the other inlet points along the River Murray (DHI 2013). Once the maximum, desired inundation extent has been achieved, the G5 outlet will be opened to a degree and maintenance flows provided to retain an area of inundation for the required duration. Outflows will occur (after the filling phase) from the forest floodplain to the River Murray as occurs naturally.

In summary, the indicative inflow pattern will be (Figure 9-2)

- gradual ramp up with filling at peak flows 250 ML/day for 11 days to achieve the desired inundation extent (75.8 mAHD at G5 outlet)
- opening the G5 outlet (partially for fish exit) and reducing inflow from 250 ML/day to 50 ML/day
- providing maintenance inflows at 50 ML/day for about 110 days to meet the duration requirements of the River Red Gum forests (with approx. 20-33 ML/day return flows to the River Murray during this period)
- gradual ramp down of inflows.

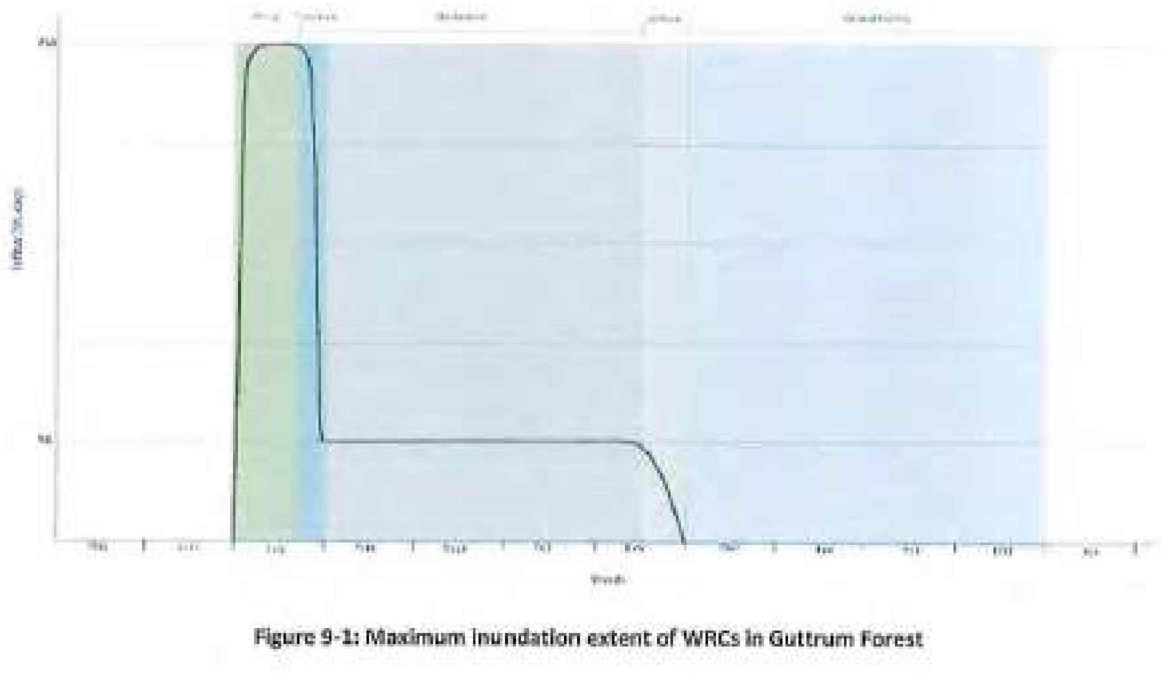


Figure 9-1: Maximum inundation extent of WRCs in Guttrum Forest

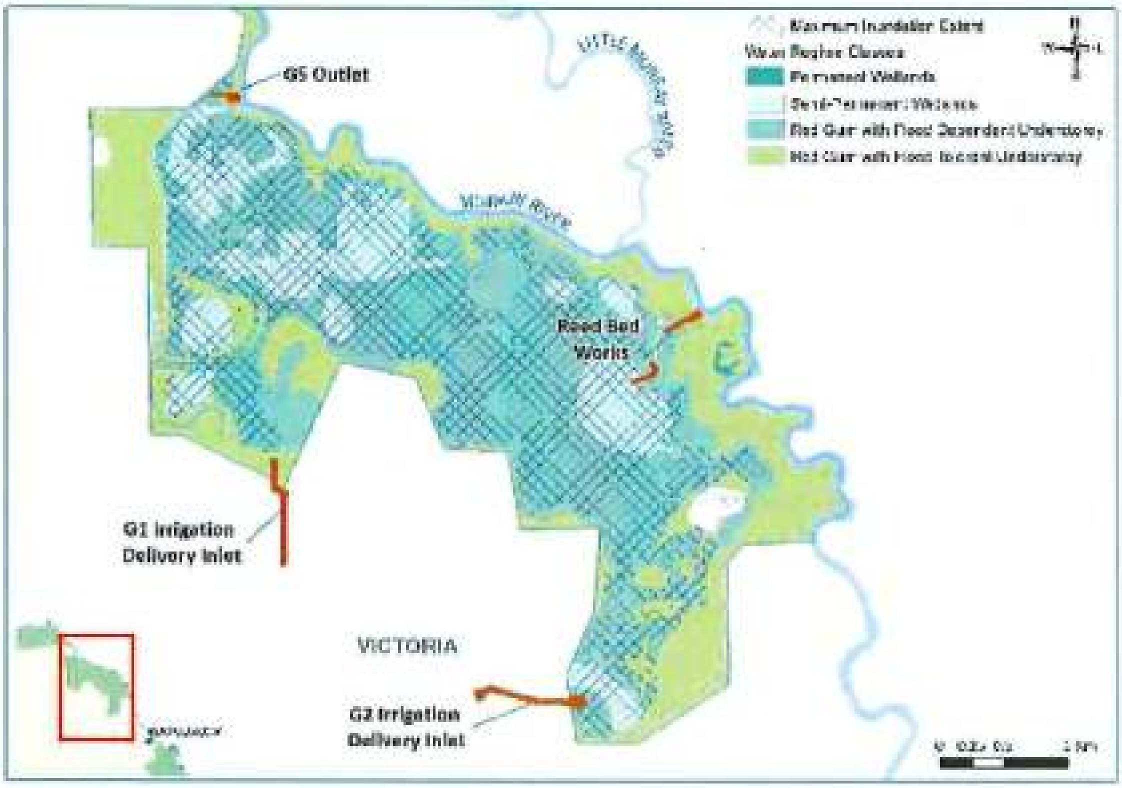


Figure 9-2. Maximum inundation extent of WRCs in Guttrum Forest

Figure 9-3: Conceptual diagram of the River Red Gum watering scenario – Guttrum Forest

Table 9-2 summarises some of the key water delivery information relating to this scenario.

Table 9-2: Guttrum Forest River Red Gum watering scenario

Component of water delivery	Proposed operation for River Red Gum watering scenario
Frequency of delivery	3 years in 10 (inundation in other years provided through natural flooding and Basin Plan flows to achieve the 8 in 10 flooding frequency)
Timing	Winter/spring *[Late winter inflows and spring drawdown so floodplain water is available in River Murray at time of in-channel spawning.]*
Peak filling inflow rate	250 ML/day (DHI 2013)
Delivery time (days to fill from dry)	11 days (DHI 2013)
Maximum inundated area	727 ha (DHI 2014a)
Maintenance inflow rate	50 ML/day (DHI 2014a)
Duration of delivery once floodplain full (maintenance phase) i.e. to achieve 4 month optimum duration	110 days (i.e. 3.5 months)*
Drying time (days to dry for RRG forests once outflows to the River Murray cease)	14 days (DHI 2014a)
Inflow volume (excluding ramp up, ramp down and contingencies)	8,250 ML
Return flow to River	3,079 ML (37% of inflow volume)
Net volume used	5,171 ML

*Does not take into account fill time (11 days), so that forest areas nearer to the outlet also receive their duration requirements. i.e. takes 11 days for water to reach this location.

9.3.2 Benwell Forest

Water will be delivered to the forest via the No. 4 irrigation supply channel using the southwest corner inlet, with the regulators at low points along the River Murray closed to achieve the required inundation extent (DHI 2013). The profile of the western bank of the river will be raised in places to prevent outflows during delivery (DHI 2013). Once the maximum, desired inundation extent has been achieved (481 ha, Figure 9-4), one or both outlets will be opened to a degree and maintenance flows provided to meet duration requirements. Outflows will occur (after the filling phase) from the forest floodplain to the River Murray as occurs naturally.

In summary, the indicative inflow pattern will be (refer to Figure 9-4 as a guide):

- gradual ramp up with filling at peak flows 250 ML/day for 15 days to achieve the desired inundation extent (75.0 mAHD at B13 outlet).
- Opening the B13 and/or B7 outlet (partially for fish exit) and reducing inflow from 250 ML/day to 50 ML/day.

- Providing maintenance inflows at 50 ML/day for about 110 days to meet the duration requirements of the River Red Gum forests (with approx. 19-33 ML/day return flows to the River Murray during this period).
- gradual ramp down of inflows.

Table 9-3 summarises some of the key water delivery information relating to this scenario.

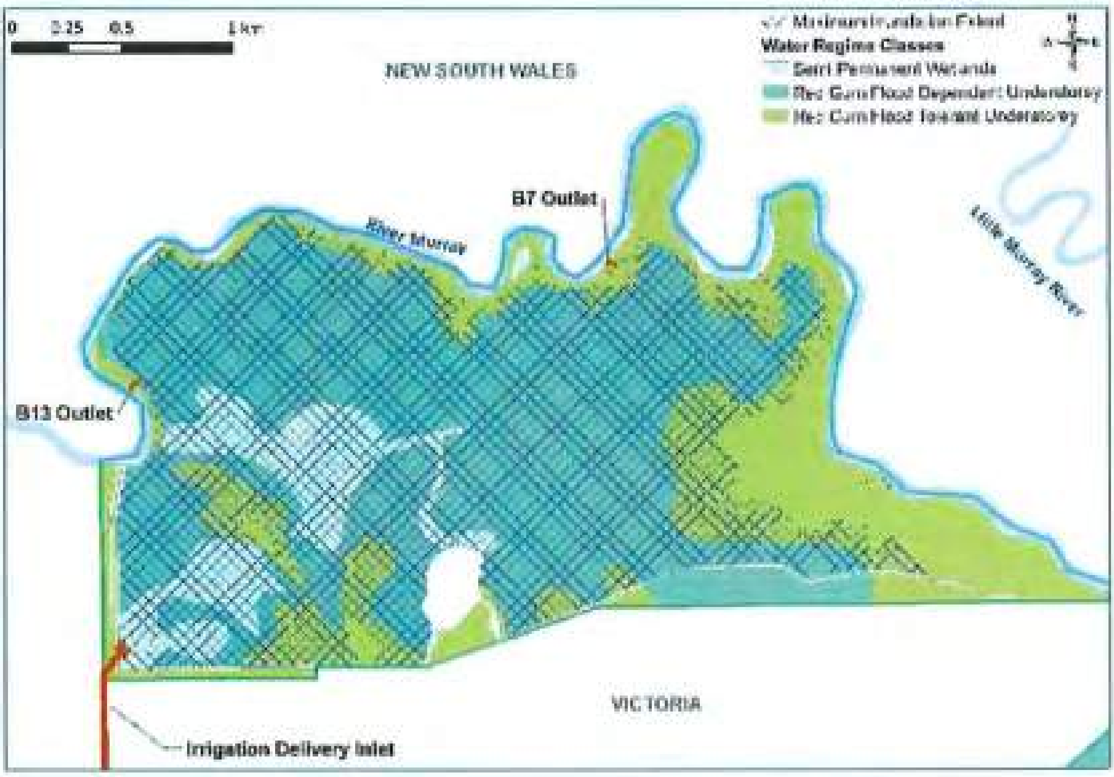


Figure 9-4. Maximum inundation extent over WRCs in Benwell Forest

Table 9-3. Benwell Forest River Red Gum watering scenario

Component of water delivery	Proposed operation for River Red Gum watering scenario
Frequency of delivery	3 years in 10 to achieve the 8 in 10 flooding frequency
Timing	Winter/spring *[Late winter inflows and spring drawdown so floodplain water is available in River Murray at time of in-channel spawning.]*
Peak filling inflow rate	250 ML/day (DHI 2013)
Delivery time (days to fill from dry)	15 days (DHI 2013)
Maximum inundated area	481 ha (DHI 2014a)
Maintenance inflow rate	50 ML/day (DHI 2014a)
Duration of delivery once floodplain full (maintenance phase) i.e. to achieve 4 month optimum duration	110 days (i.e. 3.5 months)*
Drying time (days to dry for RRG forests once outflows to the River Murray cease)	14 days (DHI 2014a)
Inflow volume (excluding ramp up, ramp down and contingencies)	9,250 ML
Return flow to River	2,990 ML (32% of inflow volume)

Net volume used	6,260 ML

*Does not take into account fill time (15 days), so that forest areas nearer to the outlet also receive their duration requirements. i.e. takes 15 days for water to reach this location.

9.4 Semi-permanent wetland watering

The semi-permanent wetland (SPW) watering scenario will: extend the duration of inundation from managed and natural events to meet the duration requirements of this water regime class and; when required, provide water to wetlands from dry to meet frequency requirements. Broadly, semi-permanent wetlands receive water in Guttrum Forest with River Murray flows of 23,000 ML/day and Benwell Forest with flows of 21,000 ML/day.

As outlined in previous sections, there is a current gap in the frequency and duration requirements of two to three years in ten and four months respectively. Under Basin Plan (2,750 GL) conditions (BP2750 April 2013 daily flow time series), the shortfall is reduced to two years in ten with a three to four month duration deficit (Gippel 2014).

If the River Red Gum watering operating scenario is implemented the SPW will receive additional inundation events of two to three years in ten, thus meeting the frequency requirements of this water regime class (see below). Of note, this is reliant on natural events occurring as modelled.

- Target frequency: 9 years in 10
- Frequency under Basin Plan 2750: 7 years in 10 (at 23,000 ML/day, rounded for simplicity) (Gippel 2014)
- Additional frequency from River Red Gum watering scenario: 3 years in 10 (if all events delivered to a dry floodplain)
- Maximum total frequency (current plus managed): 10 years in 10.

Under these conditions, SPW watering is not required to achieve the required frequency of flooding for the wetlands. The typical operating regime for wetlands would therefore be the topping up of natural flood events to achieve the duration requirements. During managed events these will be met by the River Red Gum watering scenario (with four months of inflows and up to four months for the wetlands to dry out). Meeting the duration requirements of wetlands is critical to ensure that ecological objectives are met, and to reduce the likelihood of adverse ecological impacts, such as River Red Gum encroachment.

From an operational perspective it is highly likely that watering of wetlands from dry will be required in years when modelled flows are not realised in the River Murray, or when there is insufficient water or natural cues to implement the River Red Gum watering scenario. The Project does therefore enable targeted delivery of water to the wetlands from dry across both forests e.g. during extended drought periods such as experienced in the Millennium Drought.

9.4.1 Guttrum Forest

Water will be delivered to the semi-permanent wetlands via the No. 4 irrigation supply channel using the southeast and southwest corner inlets, as outlined in Table 9-4. To inundate the eastern wetlands, water will flow across the portion of floodplain connecting the irrigation inlet to Reed Bed Swamp and Little Reed Bed wetland.

At peak top-up inflows (15 ML/day) approximately 135 ha will be inundated outside the wetlands (DHI 2014a). The operating regime will be adaptively managed to provide a balance between the delivery of top-up flows to extend natural flood duration in the wetlands and the need to prevent overwatering of the River Red Gum forest to the south and west of the wetlands.

To inundate the western wetlands, water will be delivered into the southern corner of the wetland system from the supply channel.

No outflows to the River Murray are likely to occur from wetland watering, as the G5 outlet is located at the far north-western end of the forest and begins to outflow at forest water levels above 75.5 mAHD (DHI 2013). Wetland water levels near this outlet will be in the vicinity of 75.5 mAHD, therefore water will typically remain in this wetland until it is lost through seepage and evaporation (DHI 2013). However, if required, the outlet could be closed during wetland watering to prevent outflows.

In summary, the indicative inflow pattern for wetland top-up will be:

Eastern wetlands

- providing top-up inflows of about 12 ML/day for the deficit period (83 days median modelled deficit) to meet duration requirements. Note: 12 ML/day has been estimated as the inflow rate needed to cover evaporation/seepage losses in early-mid spring. Smaller inflows will be required during winter and slightly higher inflows (about 15 ML/day) will be required during late spring/summer (DHI 2013).

Western wetlands

- providing top-up inflows of 20 ML/day (DHI 2013) for the deficit period (83 days median modelled deficit) to meet the duration requirements of the wetlands.

Note: Wetlands tend to pond water for a month or more before substantial areas of each wetland dry out (DHI 2013). The delivery rate and duration of delivery will therefore need to be adapted in response to conditions, including changes in evaporation over time.

Table 9-4 summarises some of the key water delivery information relating to this scenario.

Table 9-4: Guttrum Forest semi-permanent wetland watering scenario

Component of water delivery	Proposed operation for topping up semi-permanent wetlands
Frequency of delivery	7 years in 10 (approximate natural flooding frequency of wetlands)
Timing	Winter/spring (timing of natural flooding of wetlands)
Maximum inundated area	267 ha (DHI 2013) Includes 60 ha in eastern wetlands (approx. 50 ha in Reed Bed Swamp and 10 ha in Little Reed Bed) and 207 ha in western wetlands – approx. 20 ha in south-western wetland, 122 ha in Guttrum Swamp and 65 ha in north western wetland)
Peak inflow rate	15 ML/day (DHI 2014a) for eastern wetlands 20 ML/day (DHI 2014a) for western wetlands
Drying time (days to dry for wetlands once outflows to the River Murray cease)	Generally 121 days minimum (DHI 2014a). Refer to operating plan for further details.
Desired duration of inundation for wetlands (from hydrological requirements)	186 days (i.e. 6 months)
Top-up duration - median days of delivery after natural inflows cease	83 days (i.e. 2.6 months)

9.4.2 Benwell Forest

Water will be delivered from the No. 4 irrigation system using the new southwest corner inlet. This will deliver water directly into Southwest Benwell Swamp where it will flow north into Benwell Swamp (DHI 2014a).

Outflows are not expected through the B13 outlet (located at the western end of Benwell Swamp) due to the wetland water levels at this location (DHI 2014a). Water will gradually evaporate and infiltrate.

In summary, the indicative inflow pattern for wetland top-up in Benwell Forest will be:

- providing top up inflows of about 7.5 ML/day (DHI 2013) for the deficit period (83 days median modelled deficit) to meet the duration requirements of the wetlands. Note: about 20 ML/day may need to be delivered so that the required 7.5 ML/day enters the forest (to account for losses along the supply channel).

Table 9-5 summarises some of the key water delivery information relating to this topping up scenario.

Table 9-5: Water delivery summary for topping up semi-permanent wetlands – Benwell Forest

Component of water delivery	Proposed operation for topping up semi-permanent wetlands
Frequency of delivery	7 years in 10 (approximate natural flooding frequency of wetlands)
Timing	Winter/spring (timing of natural flooding of wetlands)
Maximum inundated area	60 ha (DHI 2014a) – approx. 20 ha in Benwell Swamp and 40 ha in Southwest Benwell Swamp
Peak inflow rate	7.5 ML/day (DHI 2013) into forest. 20 ML/day may be needed to achieve this inflow rate at the forest inlet point.
Drying time (days to dry for wetlands once outflows to the River Murray cease)	121 days minimum (DHI 2013)
Desired duration of inundation for wetlands (from hydrological requirements)	186 days (i.e. 6 months)
Top up duration – median days of delivery after natural inflows cease	83 days (i.e. 2.6 months)

Top up flows will ensure that duration requirements of the semi-permanent wetlands are met. The trigger for this scenario is a natural event in the River Murray, that provides inundation of this water regime class. Water would then be provided immediately following the cessation of natural inflows. Modelling suggests that Benwell Swamp and the wetlands surrounding Guttrum Swamp reduce in area by 40 percent and 50 percent (respectively) after 14 days of inflows ceasing (DHI 2014a).

Colonial waterbird breeding

The Reed Bed Swamp semi-permanent wetland in Guttrum Forest and the Southwest Benwell Swamp in Benwell Forest contain important colonial waterbird breeding sites (Ecological Associates 2013; G. Smith, pers. comm., October 2014). Therefore it is probable that top-up flows to the semi-permanent wetlands of Guttrum Forest and Benwell Forest may result in a bird breeding event. However, an event in response to this operating scenario (topping up a small natural flood) is likely to be significantly smaller than an event triggered by large floods that inundate the broader floodplain, and is also likely to attract a restricted range of species (e.g. less likely to attract egrets due to a limited food supply) (North Central CMA 2010a). The need for ongoing deliveries to support waterbird breeding in either forest will be assessed on an event by event basis.

9.5 Hybrid watering scenario

The hybrid watering scenario will provide top-up flows to extend the duration of natural flood events within the Guttrum and Benwell Forests.

There are two options for extending the duration of natural floods that inundate the broader forest:

- *Flood capture* – to retain floodwater on the floodplain for the required duration by closing the outlet regulators and low-lying inlet regulators from the River Murray after the river flow peak has passed.
- *Channel deliveries* – to top up the natural inflows with additional volume from the channel system at up to 250 ML/day delivered into the forests via new channel extensions.

These options are likely to be used together; however, this may depend on the situation. For example, the timing of any natural flooding will be important when determining if flood capture is appropriate – capturing flood water and ponding it over the warmer summer months may increase the risk of low-oxygen levels in the water.

There are two important ecological drivers regarding the timing of deliveries under this scenario. Firstly, to maximise outcomes for in-channel native fish recruitment (a Project objective) it will be important to provide floodplain outflows that contain food for fish larvae to the River Murray after spawning has occurred by flow-cued spawners (e.g. Golden Perch and Silver Perch) and/or temperature-cued (spring/summer) spawners (all other native fish species) (Mallen-Cooper et al. 2014).

Secondly, it will be important to avoid drawdown of water in the wetlands during spring to early summer (Ecological Associates 2013), which will promote germination of River Red Gums and potentially further encroachment. Instead drawdown in late summer/autumn is preferable (North Central CMA 2014c). Following the inflows ceasing at the end of November, the wetlands will pond water for four months, meaning the drawdown period will reflect that which occurred under natural conditions.

9.6 Role of operating structures

The role of each engineering structure required for the operating scenarios is outlined below.

Table 9-6: Role of structures in operations

Operating structure	Role in operations	Operating scenario(s) the structure is applicable to*
Guttrum Forest		
G1 inlet regulator (southwest corner of forest)	Enables water delivery to the SPW in the western half of the forest i.e. Guttrum Swamp complex. Provides operational flexibility for River Red Gum FDU watering by enabling water delivery to the western half of the forest in combination with the G2 inlet regulator.	SPW watering River Red Gum watering Hybrid watering
G2 inlet regulator (southeast corner of forest)	Enables water delivery to the entire floodplain (River Red Gum forests and semi-permanent wetlands). Enables water delivery to the semi-permanent wetlands in the eastern half of the forest i.e. Reed Bed Swamp and Little Reed Bed wetland.	River Red Gum watering SPW watering Hybrid watering
G5 (new) outlet regulator	Controls outflows from the floodplain i.e.: • Preventing return flows during the filling phase of a River Red Gum watering event so that the desired supply level and associated inundation area is achieved • Contributing to the provision of adequate through-flow during the maintenance flow phase of a River Red Gum watering event to reduce stagnation, which can contribute to low Dissolved Oxygen	River Red Gum watering

	levels • Enabling fish passage from the floodplain to the River Murray.	
Benwell Forest		
B1 inlet regulator (southwest corner of forest)	Enables water delivery to the entire floodplain (River Red Gum forests and semi-permanent wetlands). Enables targeted water delivery to the semi-permanent wetlands i.e. Benwell Swamp and Southwest Benwell Swamp.	River Red Gum watering Semi-permanent wetland watering Hybrid watering
B7 inlet regulator	Controls outflows from the floodplain i.e.: • Preventing return flows during the filling phase of a River Red Gum watering event so that the desired supply level and associated inundation area is achieved • Contributing to the provision of adequate through-flow during the maintenance flow phase of a River Red Gum watering event to reduce stagnation, which can contribute to low Dissolved Oxygen levels • Enabling fish passage from the floodplain to the River Murray.	River Red Gum watering Hybrid watering
B13 outlet regulator	Controls outflows from the floodplain i.e.: • Preventing return flows during the filling phase of a River Red Gum watering event so that the desired supply level and associated inundation area is achieved • Contributing to the provision of adequate through-flow during the maintenance flow phase of a River Red Gum or semi-permanent wetland watering event to reduce stagnation, which can contribute to low Dissolved Oxygen levels • Enabling fish passage from the floodplain to the River Murray.	River Red Gum watering Semi-permanent wetland watering Hybrid watering

* All structures are applicable to hybrid events

Note: a spillway also exists near the primary outlet regulator in each forest (G5 new and B13). These have been designed to enable outflows from large natural floods to pass safely from each forest back into the River Murray. Depending on how the outlet regulators are operated (i.e. to what degree they are open), return flows to the River Murray during fully managed events may occur either entirely, partially or not at all via these spillways.

9.7 Operational considerations

The *Guttrum and Benwell Forests Environmental Works Project* proposes to connect the forests to an alternative water supply - the Torrumbarry Irrigation Area - to meet the flooding regime requirements of the forests. The successful implementation of operating scenarios therefore depends on the physical capacity of the system to deliver the required flows, time of year and demand from other customers.

In Victoria, environmental water can be suppled from the irrigation network via the following:

Delivery Share: Entitles the holder to a 1 ML/day share of the channel system capacity during the irrigation season (15 August to 15 May). Priority access is given to delivery share holders

Casual User: A guaranteed supply once order is placed. First to lose access if water restrictions or demand from delivery shareholders.

Interruptible Supply: Lowest level of security with access only available once other customers' demands met.

Note: this is the current framework for delivery within Victoria and is subject to change. Under current operational conditions, it is proposed that the majority of water delivered to the Guttrum and Benwell Forests would be provided as interruptible supply. The following section discusses this in more detail.

9.7.1 Torrumbarry Irrigation Area

The Torrumbarry Irrigation Area covers 167,000 ha in northern Victoria and extends along the River Murray from Gunbower in the east to Nyah in the west and includes the towns of Koondrook, Cohuna, Kerang and Swan Hill

(GMW 2009). It is managed by G-MW and consists of a complex distribution network of natural waterways and 1400 km of manmade irrigation channels.

The district originates from Torrumbarry Weir where water from the River Murray is diverted through the National Channel Offtake into the National Channel. The National Channel (approximately 4,000 ML/day capacity) is a straightened and enlarged section of what was originally Gunbower Creek. Water can either be diverted into Gunbower Creek at Gunbower Weir, or continue down Taylor's Creek to supply the Number 1 and 2 channel systems, or enter into storage at Kow Swamp. Gunbower Creek has a number of weirs and regulators that feed irrigation channels and supply wetlands in the Gunbower Forest (e.g. Reedy Lagoon and Black Swamp) (North Central CMA 2010). The Koondrook Weir is upstream of the Koondrook Spillway where water re-enters the River Murray. Koondrook Weir supplies the No. 4 channel with a reported capacity of approximately 660 ML/day. The No. 4 channel supplies irrigators west of Koondrook and is the proposed channel to supply the Guttrum and Benwell Forests.

9.7.2 Capacity

Preliminary investigations were undertaken to determine the viablity of the proposed operational scenarios within the constraints of the irrigation system. The investigations suggest 250 ML/day of free capacity exists within the applicable parts of the irrigation system virtually all year round (see

Figure 9-5 below from G-MW showing minor constraints in early September and April/May potentially). This means that operation can occur within the irrigation season (August to May) with a low risk of not being able to deliver inflows. Any capacity constraint issues will be monitored and managed in conjunction with G-MW. It is important to note that the modelling was undertaken on one particular year that was selected because it was dry, and there was a high level of customer deliveries. Further modelling work will be required to explore any potential constraints in other years.

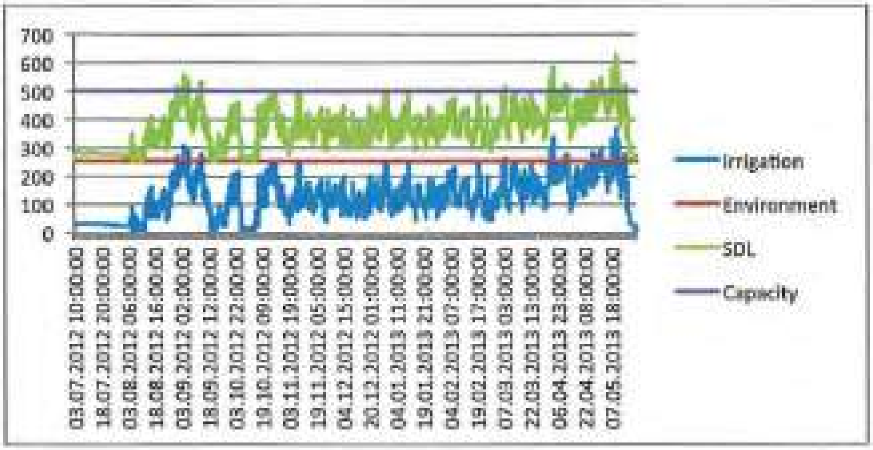


Figure 9-5: Capacity within the Torrumbarry Irrigation Area system (Source: GMW 2014)

9.7.3 Delivery pattern options

In years where both Guttrum and Benwell Forests require watering under the River Red Gum watering scenario deliveries to the forests are proposed to occur as outlined below. This pattern of delivery will maximise the ecological benefits and minimise impacts on the GMW channel maintenance/capital works program, which is normally scheduled for the irrigation off-season.

Irrigation off-season- July (500 ML/day free capacity) – deliver peak flows (250 ML/day) into both Guttrum Forest and Benwell Forests for the required filling period. Utilise full capacity of the No. 4 channel.

Irrigation season - **August to November** (250 ML/day free capacity) – deliver maintenance flows (50 ML/day) into both forests for approximately four months. Spare capacity remaining is 400 ML/day

If the entire watering event was restricted to the irrigation season (e.g. due to non-negotiable G-MW maintenance/capital works conflicts) then the following could be undertaken (single theoretical example) to enable dual operation

- **Mid to late August** (250 ML/day free capacity) – deliver peak flows (250 ML/day) into Benwell Forest for 15 days
- **September** (variable free capacity based on Figure 5, 200-250 ML/day) – deliver maintenance flows (50 ML/day) into Benwell Forest and deliver maximum flows (150-200 ML/day) into Guttrum Forest until the desired supply level is reached (more than 11 days but expected to be complete by end September).
- **October to December** (250 ML/day free capacity) – deliver maintenance flows (50 ML/day) into both Benwell Forest and Guttrum Forest. This sees the maintenance flow period for Benwell Forest completed. Benwell Forest wetlands will retain water until the end of April
- **January** (250 ML/day free capacity) – deliver maintenance flows (50 ML/day) into Guttrum Forest. Spare capacity remaining is 200 ML/day. This sees the maintenance flow period for Guttrum Forest completed. Guttrum Forest wetlands will retain water until the end of May.

The above examples highlight that there is a large degree of flexibility and adaptability in how the operational scenarios can be implemented. This provides increased assurance that achievement of the Project's ecological objectives will not be inhibited by any of the identified potential constraints to delivery

10 Socio-economic impacts from operation

The methodology for assessing the risks has been briefly outlined in Section 6 and further information is provided in the *Risk Management Strategy*. Potential adverse ecological impacts fom operation are discussed in Section 6 and the Project development and construction risks are discussed in Section 17.

This section describes the potential adverse impacts that may result from operation of the supply measure on socio-economic and cultural heritage values.

10.1 Overview

Guttrum and Benwell Forests are multi-use sites and have a range of social and economic values and benefits for local and regional communities. Commercial uses of the forests include timber harvesting and domestic timber collection, as part of the mid-Murray Forest Management Plan Area, domestic stock grazing, apiculture (bee keeping), and sand mining. The number of licences for the other commercial activities is shown in Table 10-1.

Table 10-1: Commercial activity licences in Guttrum and Benwell Forests

Licence Type	Forest	Number of Licences
Grazing	Guttrum	4
	Benwell	1
Apiculture	Guttrum	5
	Benwell	1
Sand extraction	Guttrum	1
	Benwell	1
Tourism operators	Across both forests	49

Social and recreational uses include dispersed camping, horse riding, four-wheel driving, bird-watching and sightseeing pursuits.

The results of the risk assessment for social and economic values of the forests is shown in Table 10-2.

Table 10-2: High priority socio-economic risks

Risks	Initial risk			Residual risk		
	Likelihood	Consequence	Rating	Likelihood	Consequence	Rating
Loss of access for recreation	Likely	Moderate	High	Possible	Minor	Moderate
Loss of access for licence holders	Likely	Moderate	High	Possible	Minor	Moderate
Third party flooding	Likely	Moderate	High	Unlikely	Minor harm	Low
Loss of cultural heritage	Possible	Major harm	Moderate	Unlikely	Major harm	Moderate

10.2 Loss of access

Environmental watering of the forests will temporarily reduce access in years when watering is taking place, as would be the case when natural flooding occurs. This will restrict the social and economic uses of the forests which are dependent on access to their resources. The social benefits from flooding, such as increased opportunities for recreational uses and improved aesthetics of the forest, will offset some of the potential impacts. Also, indirect outcomes such as the increased productivity and growth of River Red Gums will benefit some users for e.g.

apiarists and timber licence holders. However, other measures will be needed – primarily around appropriate communication and engagement activities - to mitigate residual impacts.

The mitigation controls involve a number of elements described in further detail below.

Rights of access to the forests to harvest timber, extract sand and manage beehives are subject to licences. Information such as this contained within licences ensures that licensees understand the potential implications that watering of the forests may have on their activities. Subsequently there is the opportunity to plan and adapt their usage around the sites' accessibility.

Standard licence conditions for apiarists include that the licensee may be required to remove beehives from or not place beehives within the licence area to allow the public land manager to conduct management operations (DEPI, 2014b). Early warning to bee-keeping licence holders before watering commences will allow time to adjust operations. For example, bee hives may be placed on the outer edge of the flooding extent, and the bees can still use the forest, which is likely to exhibit more flowering as a result of the flooding.

The *Stakeholder Management Strategy* (discussed in Section 13) will be updated following approval to proceed with the Project. Key engagement and communication activities will be informed by the particular phase of the Project and the individual needs of the key stakeholders. Clear and timely communication of planned watering activities will be a key component of this. Engagement with tourist information centres to ensure that visitors have appropriate and up-to-date information will be one tool used to reduce the impacts of flooding of the forests on forest access.

The North Central CMA prepares annual seasonal watering proposals for all sites that are to receive environmental water, under Victoria's environmental water allocation framework. Developing the proposals involves consultation and engagement with environmental water advisory groups, comprised of interested community members and stakeholders. This process ensures that all parties' interests are considered in planning and implementing any watering event.

The Project overall will help to restore and maintain socio-economic recreational and tourist values - albeit at the risk of limiting access for periods of time. The cost benefit assessment in Section 13.8 confirms the major potential benefits from enhanced watering for recreation and the regional economy.

With these controls in place the residual risks for these potential impacts is deemed to be 'possible' with a 'minor impact' generating an overall risk rating of 'Moderate'.

10.3 Cultural heritage

Flooding of the Guttrum and Benwell Forests has the potential to impact on cultural heritage sites by inundating areas of cultural sensitivity. The cultural heritage management plan, in development for the Project, will ensure that these impacts are considered in the implementation and operation phases. In addition, the North Central CMA is undertaking project work with Guttrum and Benwell Forest's Traditional Owners to progress the development of meaningful cultural flow objectives to enhance and complement the ecological objectives for the Guttrum and Benwell Forests.

10.4 Third party flooding

Guttrum and Benwell Forests are bordered by agricultural land to the south. Historically, this agricultural land would have formed part of the broader River Murray floodplain. The cleared agricultural land however is now protected by a system of levees, constructed by landholders to provide protection from natural flood events. The current levee banks in the Guttrum and Benwell Forests provide a level of flood protection greater than the equivalent 26,000 ML/d inundation extent proposed by this Project. However, there is a risk of third party impacts associated with private land flooding should the levees fail.

In order to demonstrate that this risk can be adequately mitigated for this proposed supply measure, an informed risk assessment was undertaken (Water Technology 2014), accompanied by the development of a comprehensive suite of potential risk mitigation options. This assessment was underpinned by scenario-based hydraulic modelling (DHI 2014b; Water Technology 2014) and levee condition assessments (DHI 2014b; Water Technology 2014). The hydraulic modelling reports and the risk assessment were reviewed by the Expert Review Panel for Victorian supply measure business cases, who determined the process and work undertaken to be fit for purpose.

The risk assessment (Water Technology 2014) indicated that the risk of levee failure varied considerably depending on location. Potential mitigation options are aimed at both reducing the likelihood of levee failure/overtopping and minimising consequences or avoiding litigation if a levee failure/overtopping did occur. Table 10-3 provides a summary of the mitigation options that will be further investigated for their implementation viability during the detailed design phase (i.e. post-business case submission). It is anticipated that potential mitigation options will be assigned to each risk category (e.g. low/moderate/high/extreme) at this time.

Table 10-3: Potentially Viable Mitigation Measures for Further Consideration.

Option Aim	Mitigation Options
To reduce the likelihood of failure/overtopping	• Levee upgrades • Levee maintenance* • Monitoring levee condition • Manage rates of rise /drawdown during watering
Minimise consequences if failure/overtopping occurs	• Emergency response procedure • Communications plan • Upgrade existing management to provide mitigation • Raise access roads and tracks
Avoid litigation if failure/overtopping occurs	• Landholder agreements • Floodway easements

*Note that levee maintenance can be enabled in a variety of ways however all require permits under relevant legislation.

In presenting the risk assessment in this Business Case, it is noted that key policy matters that will inform the final risk management strategy for this proposed supply measure cannot be formally determined at this time. This includes any final decision-making on which mitigation options will be selected for implementation, including who owns and maintains the levees.

DEPI will be in a position to provide more formal advice on the state's preferred long-term risk mitigation arrangements for this supply measure once the full suite of Victorian proposals under the SDL adjustment mechanism has been more definitely scoped. This will occur as early as possible in 2015.

11 Technical Feasibility and Fitness for Purpose

11.1 Overview

This section of the Business Case provides an overview of the technical feasibility of the Project's infrastructure package. It outlines the options analysis, design criteria and the location and features of the infrastructure. The information presented is a summary from the *Concept Design Report* for Guttrum and Benwell Forests, which includes the concept design report, design drawings, and construction cost estimates (URS 2014).

11.2 Options analysis

A number of background investigations and studies were undertaken to inform and support the selection of an infrastructure package for the Project. Alternative options were assessed on their benefit, feasibility, cost and risk and included significant input from partner agencies and the Expert Review Panel. A summary of the design principles and options assessment is provided below.

11.2.1 Design principles

The following principles were applied in selecting the design for the works and operating regime:

- Natural patterns: Build on and mimic natural flows and flow paths
- Targeted: focus on the specific watering requirements of water-dependent flora and fauna
- Minimum impact:

– Low intrusion footprint: build assets in previously disturbed areas or outside the forest boundary

– Minimise adverse impacts on the forest, including the risk of overwatering of more terrestrial vegetation

– Minimise impacts and risks to third parties, e.g. an inundation pattern to minimise pressure on levee banks

- Effective: robust simple assets that will be effective and resilient over time
- Flexible: capable of adaptive management to respond to the outcomes of the monitoring program to meet the various water requirements of the flora and fauna communities and to respond to climate change
- Low cost: to construct and operate.

11.2.2 Options assessment

Phase 2 of the Project assessed five options for delivering environmental water, listed in

Table 11-1. Further detail is provided in the *Guttrum and Benwell Forest Infrastructure Options Assessment* which is a supporting document to this business case. Options were assessed on their ability to deliver added benefit to the project, feasibility, cost and risk, using all available information from the Project's various investigations.

Table 11-1: Guttrum and Benwell Forests – Options analysis

#	Option	Description
1	Channel deepening	Lowering inlet channel so River Murray water can enter at lower flow rates
2	Effluent regulators	Hold water on the floodplain to extend duration of inundation
3	Influent regulators	Prevent flows entering the forest
4	Irrigation supply	Water delivered to the forest from the Goulburn Murray Irrigation District
5	Pumping	Water pumped into the forest from the River Murray

Source URS (2014)

The following provides further information on the options analysed.

Channel deepening

This option involves deepening natural forest effluents on the River Murray. It is a relatively low cost option that was discarded due to the requirement for major works within the river bank. It was also found to be only marginally effective in increasing the frequency of inundation, requiring a minimum river flow of 16,000 ML/day to begin with broad floodplain inundation not occurring below 26,000 ML/day. The reliance on River Murray flows was considered to be in adequate in meeting the watering requirments of the sites.

Effluent regulators

Structures on the effluents could be operated to prevent flood flows returning to the River Murray when the river level drops. They were found to be effective in extending the duration of the inundation, and were simple and robust to construct and operate.

Influent regulators

These structures provide the ability to exclude high River Murray flows in scenarios where water entering the forest is undesirable, such as at the peak of an environmental watering event. These structures would minimise perimeter levee breach risks. This option was assessed as unfeasible as the regulators would be difficult to access and operate in the event of a major flood, and would only be effective and required in limited situations. They were also a high additional cost to the Project.

Irrigation supply

This option involves the construction of short channels to connect to the irrigation system and enable environmental water to be delivered to the forests. Hydraulic modelling identified the effectiveness of this option in achieving broadscale flooding across the forests. There is limited impact from the works as they are generally located outside of the Project sites and they are low cost being reliant on a gravity feed.

Pumping

Pumping of water into the forest directly from the River Murray was deemed unfeasible for major inundation events as it requires the construction of major works for pump stations. New substations and overhead power extensions would be required to bring permanent electric power to the forest boundary and underground power would be required from the forest boundary to the pump station (URS 2014). Costs for this option were higher than the channel supply. However, a temporary pumping arrangement in Guttrum Forest to maintain wetland inundation levels for short periods at Little Reed Bed and Reed Bed swamps was selected as it enables the delivery of small flows directly to the wetlands.

11.2.3 Whole of life-cycle cost assessment

A whole of life-cycle cost analysis was undertaken to compare the irrigation supply channel and pumping (diesel and electric) options for the two forests (see Table 11-2).

Irrigation: supply channel to each forest from the Torrumbarry irrigation system. The following parameters were assumed:

- 250 ML/day flow rate
- Guttrum: 11 days flow
- Benwell: 15 days flow

Pumping: Diesel or electric pumps for:

- 100 ML/day
- Guttrum: 29 days flow
- Benwell: 44 days flow

A discounted cash flow analysis was completed for each option, as the total cost stream over 70 years returned to a present value (PV) with a 5% discount rate. The capital costs included initial construction costs and cyclical replacement costs. The operating costs were assumed to be incurred in-line with the use of the relevant assets. In the analysis the watering frequency was set at six years out of ten. It was therefore assumed that the operating costs were incurred in those years but that no costs were incurred in other years.

Table 11-2: Whole of life-cycle cost options analysis (PV over 70 years @ 5%)

Irrigation channel		Cost element	Present value
	Capex	Initial construction	$1,307,937
		Land: (2 ha @ $10,000/ha) & fencing	$25,000
	Opex	Operation (11 days @ $,500)	$68,110
		GMW Tariff	$412,373
		Total	**$1,813,419**
Pumped options		**Cost element**	**Present value**
Electric	Capex	Initial construction	$2,535,492
		Replacement (every 15 years)	$54,179
	Opex	O&M : $5,000 pa - 6/10 years	$61,918
		Power cost 6/10 years	$837,299
		Total	**$3,488,888**
Diesel	Capex	Initial construction	$1,291,264
		Rebuild (every 10 years)	$15,378
	Opex	O&M: $1,500 per month	$222,904
		Diesel costs 6/10 years	$725,084
		Total	**$2,254,631**

Source: RMCG (2014), *Guttrum and Benwell Forests - watering proposals: whole of life-cycle cost analysis*, for North Central CMA

The analysis was similar for the two forests and identified that:

- The initial capital cost was most expensive for the electric pumping option but was similar between the diesel pumps and the irrigation channel

- The operating costs were lowest for the irrigation supply option. In contrast, the power costs for the pumping options were substantial.

The costs of delivering environmental water to the sites cannot be quantified at this time. They are subject to a pending review of GMW's tariff structure. The modelling was therefore based on advice from DEPI and assumed:

- The VEWH/CMAs holds 100 Delivery Shares - which can be utilised anywhere within the Goulburn Murray Irrigation District.
- These shares give the VEWH/CMAs rights to delivery of a maximum flow of 100 x 250ML = 25,000 ML/yr.
- The holding triggers an Infrastructure Access Fee of $3,000 DS, i.e. a total cost of $300,000/yr.
- The cost would be allocated between projects pro-rata to the total volume of the watering activity.

Sensitivity analysis showed that the GMW tariff would have to double for the cost of the irrigation option to equal the diesel pumped option.

11.2.4 Preferred options

The preferred options were determined to be:

- Channels to allow environmental water to be delivered onto the floodplain from the irrigation system.
- Regulators on effluent channels to hold water on the floodplain after inflows have reduced.

Further detail is provided in Table 11-3.

Table 11-3: Summary of proposed works at Guttrum and Benwell Forests

Works	Justification
Guttrum Forest	
Regulators to contain water G5 (new) regulator including levee to restrict flow to G5 (old)	Enables the desired inundation extent and flood duration to be achieved and provides operational flexibility.
Perimeter levee works At least 230 m in 5 sections	Manage risk of flooding private land.
Irrigation supply 250 ML/day inflow at southeast corner of forest, 50 ML/day inflow at southwest corner of forest and associated works	Reliable, broadscale flooding and targetted watering to forests, independent of River Murray flows. 250 ML/day flow rate through the southeast inlet gives a greater chance of achieving ecological outcomes.
Reed Bed Swamp connection and temporary pumping Greater connectivity and flow control between Reed Bed and Little Reed Bed 5 ML/day pumped inflow from River Murray	Enhances connectivity and the ability to control flows between Reed Bed and Little Reed Bed swamps. Allows semi-permanent wetland watering from either the G2 irrigation supply or temporary River Murray pumped supply. Supports the longer duration watering required for the semi-permanent wetlands and also critically important during a colonial waterbird breeding event. The pumping option is highly flexible.
Benwell Forest	
Regulators to contain water B7 and B13 regulator and associated works	Enables the desired inundation extent and flood duration to be achieved, provides operational flexibility.
Perimeter levee works	Manage risk of flooding private land.

Works	Justification
At least 950m in 13 sections	
Irrigation supply 250 ML/day inflow at southwest corner of forest and associated works	Least expensive way (over long term) to achieve broadscale flooding. 250 ML/day flow rate provides the optimum inflow to achieve inundation area, depth and duration.

11.3 Proposed package of works

The location of works to deliver the required inundation extent, depth and duration in Guttrum and Benwell Forests is shown in Figure 11-1 and Figure 11-2. A short description of the package of works is provided below. Refer to

Appendix 6 for the *Concept Design Report* which includes the brief and design drawings (URS 2014).

11.3.1 Guttrum Forest

G1 and G2 Irrigation Channel Supply: two new and separate irrigation channels (G1 and G2) will connect the forest into the Torrumbarry Irrigation Area. Irrigation channel supply works will consist of an offtake regulating structure and road and farm drainage culvert/inverted syphon crossings.

G5 New Regulator: a new regulator and raised access track/levee at the forest outlet (G5 New) will replace an old existing structure to contain water on the floodplain and control water levels, and provide a fish exit.

Little Reed Bed – Reed Bed Swamp Connection: the connection between Little Reed Bed and Reed Bed swamps will be improved by enhancing an existing natural effluent, and the inclusion of small regulating structures. This will facilitate the movement of water between the two wetlands when flooding the forest from the irrigation system. A temporary pumping site with permanent access and civil works will also be required to enable the top-up of water levels by pumping from the River Murray.

Guttrum Perimeter Levee: construction may consist of repairs to the existing perimeter levee and new levee sections for all high 'consequence of failure' points on the north western forest boundary.

Access tracks: new levee access tracks along private property and within the forest for monitoring and maintenance where water touches/pools against the existing levee. Access tracks on top of proposed new levees are not included in this scope of work, though have been included in the construction cost estimates of the levees themselves.

G5 Old Erosion Protection Works: protecting the existing bridge, channel and outfall at G5 Old during a natural flood event or high river the flows with erosion protection.

11.3.2 Benwell Forest

B1 Irrigation Channel Supply: a new irrigation channel connection (B1) will connect the forest into the Torrumbarry irrigation system. Irrigation channel supply works include a channel offtake and forest outfall regulating structure and road and farm drainage culvert/inverted syphon crossings.

B13 Regulator: a new regulator (B13 regulator), primary spillway weir, vehicle crossing and raised forest access track/levee (B13 levee) on the natural forest effluent at B13 to contain water on the floodplain.

B7 Culvert Crossing: a small culvert river track crossing of the natural forest effluent channel at B7, with an automated dual-leaf gate (B7 outlet and culvert) to contain water on the floodplain and provide accurate water release control to allow through-flows.

Benwell Levee: construction may consist of repairs to the existing perimeter levee, or new levee sections for all 'high consequence of failure' points on the north western forest boundary.

Access tracks: required for existing perimeter levee monitoring and maintenance along private property and within the forest. Access tracks on top of proposed new levees are not included in this scope of work, though have been included in the construction cost estimates of the levees themselves.

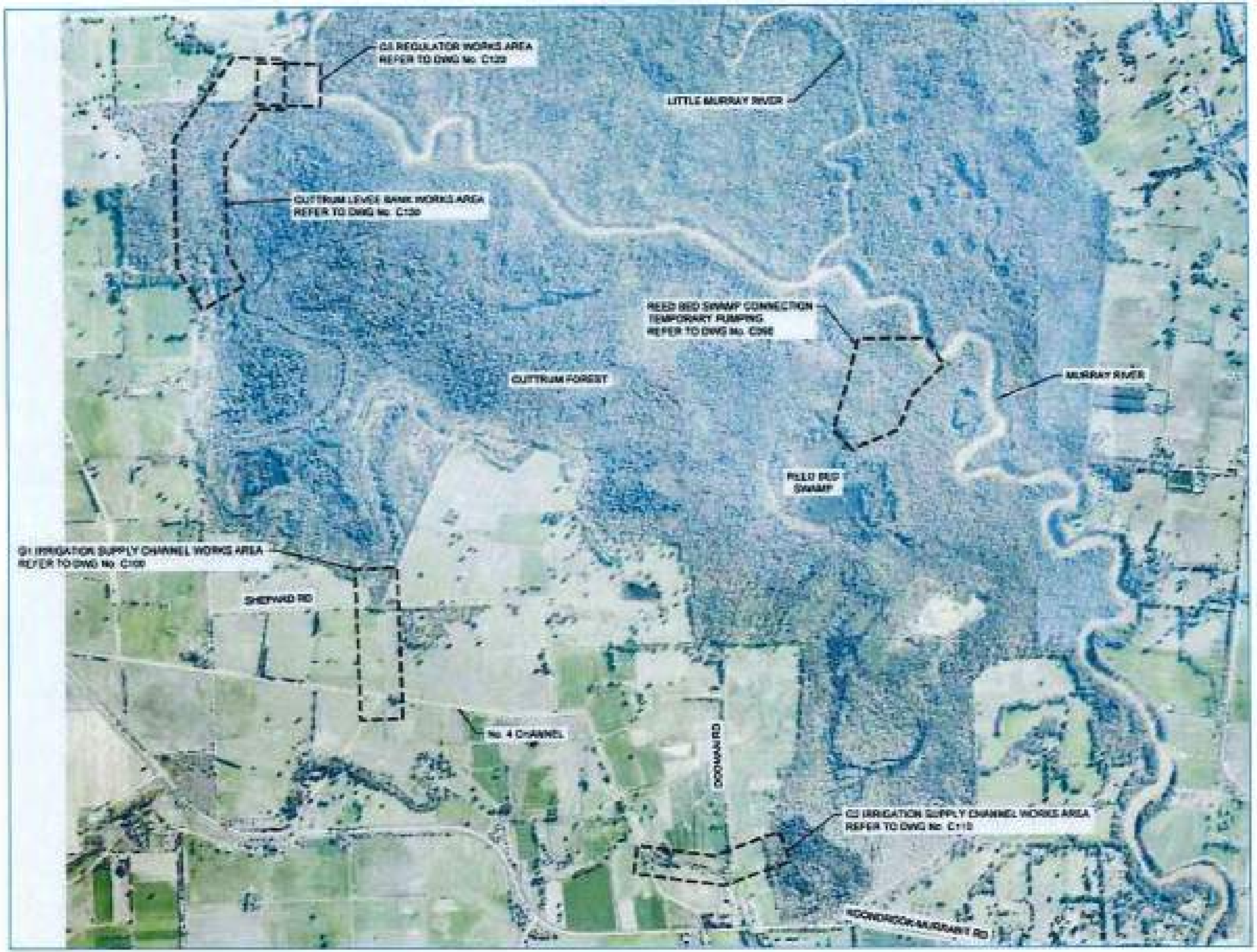


Figure 11-1: Package of works - Guttrum Forest (URS 2014)

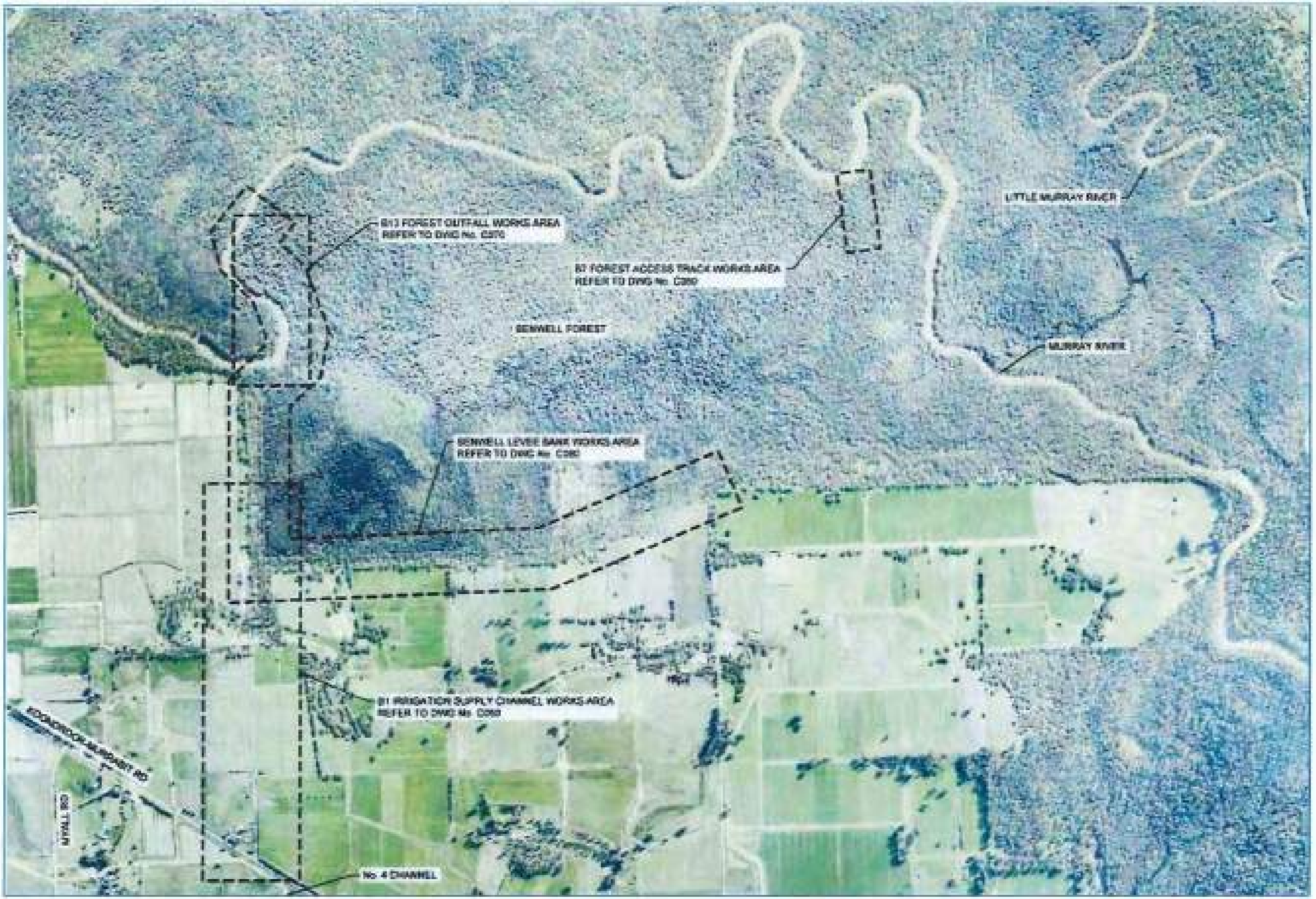


Figure 11-2: Package of works - Benwell Forest (URS 2014)

11.4 Project design criteria

The development of concept designs for the engineering works, required to deliver environmental water to Guttrum and Benwell Forests, is based on the following overall project design criteria:

- Facilitation of forest or targeted wetland flooding via the River Murray and the Torrumbarry Irrigation Area (TIA) inflows.
- Provision of the following design inflows:

– G5 New Regulator (up to 900 ML/d) via River Murray (during natural events)

– B13 Regulator (up to 850 ML/d) via River Murray (during natural events)

– B7 Regulator (up to 50 ML/d) via River Murray (during natural events)

– G1 Irrigation Supply (up to 50 ML/d) via No.4 Main Channel (TIA)

– G2 Irrigation Supply (up to 250 ML/d) via No.4 Main Channel (TIA)

– B1 Irrigation Supply (up to 250 ML/d) via No.4 Main Channel (TIA)

- Containment of water within the forest to a level of 75.8 mAHD (Guttrum) and 75.0 mAHD (Benwell).
- Manual operation of flow control structures within each forest G5 New, B13, B1 (Forest Outfall), and automated operation of irrigation offtake structures (G1, G2, B1) and B7 regulator.
- Access to each structure at all times during watering events and in forest floods, by use of the existing public roads, forest tracks and/or new access tracks.
- Provision of improved connection between Little Reed Bed and Reed Bed Swamp within Guttrum Forest to assist with temporary pumping from the River Murray to top-up Little Reed Bed and Reed Bed Swamp to achieve objectives for duration of inundation.
- Provision of safe downstream fish passage for small bodied fish through all new regulating structures, including safe fish passage from the floodplain and into the River Murray during forest draining events and low River Murray flow water levels.
- Provision of improved flood protection of private land from managed and natural inundation events along all existing high consequence of failure levee sections of each forest.
- Provision of carp/large bodied fish screens on the irrigation supply channels to prevent large fish being trapped on the floodplain.
- Provision of erosion protection works.
- Consideration of environmental and cultural heritage impacts.
- Incorporation of Safety in design principles.
- Minimisation of operation and maintenance costs.

11.5 Key design features

11.5.1 New irrigation supply channels

Three new channel connections into the irrigation system are proposed – two at Guttrum Forest (G1 and G2) and one at Benwell Forest (B1). The key parameters of these new channels are shown in Table 11-4.

Table 11-4: New irrigation channels – parameters

Parameter	G1	G2	B1
Maximum flow (ML/day)	50	250	250
Length (m)	900	845	1,500
Depth (m)	0.81	1	1.1
Width - bottom (m)	2	4	4

The channels are designed according to the following design criteria and functionality:

- To achieve the nominated flow rates.
- To provide suitable flow regulation and measuring prior to outfall.
- To maintain the current level of farm access provision including road crossings.
- To provide suitable conditions for small fish passage only through the regulator.
- To provide screens to prevent large bodied fish from entering or being stranded on the floodplain.
- To have no adverse effects on private property.
- To maintain current level of flood protection.

The construction of the channels involves a number of components:

- Offtake regulators to control flows into the new channels from the irrigation system.
- Length of channels (varying from 845 m to 1,500 m in length).
- Outfall regulators to control the discharge into the forests.
- Road and drain crossings.
- Power supply.

Figure 11-3: G1 irrigation supply channel work area locality plan (URS 2014)

Estimated costs for these structures are provided in Section **Error! Reference source not found.** with further detail in t he *Concept Design Report*. Additional costs will be incurred in the purchase of private land for the length of channels before they enter the forests, which are also detailed in Section 13**Error! Reference source not found.**.

11.5.2 Channel off-take and outfall regulators

The design includes the construction of remotely operated offtake regulating structures from the current irrigation system to the new spur channels. The B1 channel will also have a manually controlled outfall regulating structure at the point of discharge into Benwell Forest.

The offtake regulators will consist of concrete (precast) box culverts containing flume gates, and include a walkway for maintenance access over the regulator. Two gates are proposed so that, in the case of the failure of one of the gates, the structure can continue to regulate flow. This design also provides for future operational flexibility, if it is determined that a greater regulated flow is required.

Upstream and downstream key walls have been included along with rip rap and a carp screen to achieve plunge pool conditions, thus permitting safe passage for small fish downstream through the structure. Upstream and downstream rock beaching has been designed to minimise erosion and scour around the structure. To prevent against piping failure, it is anticipated that a sheet pile cut-off wall will be required directly below the regulator and extend to a depth of at least 5 m. A secondary row of sheet piles is required to a similar depth along the downstream aspect of the regulator base slab.

The B1 outfall regulator will be a concrete (precast) box culvert containing two dual leaf gates. Power supply to the site will allow for automation of the gates lifting while the process is manually controlled.

Estimated costs for the structures are provided in Section 13 with further detail in the *Concept Design Report*.

11.5.3 Road and drain crossings

The supply channels cross a number of roadways, farm tracks and existing drains. A variety of different scales of systems are employed to reflect the locations and flow requirements. Estimated costs for the structures are provided in Section 13 with further detail in the *Concept Design Report*.

Crossings at B1 channel

The supply channel crosses Koondrook-Murrabit Rd and the proposed Benwell Community Drain immediately downstream of the offtake regulator. A 17.5 m offset from the supply channel has been assumed for the proposed drain in locating this crossing. Further down the channel, two other farm track crossings are required. Two 1500 mm RCP culverts will pass under both the Koondrook-Murrabit Rd and the drain at a length of 45 m and two 1500 mm RCP culvert will pass under each of the two farm tracks, at lengths of 15 m each.

Crossings at G1 channel

The crossing of Shepards Rd and an existing farm track are required for the channel to enter the forest. Both crossings comprise two 825 mm diameter concrete pipes running underneath the tracks for 15 m. Two sets of precast concrete headwalls guide the channel banks to the pipe barrels.

Crossings at G2 channel

The crossing of Doolan Road, two existing farm tracks and an existing drain, that is to be realigned as part of the works, are required for the channel to enter the forest. All crossings comprise of three 1350 mm diameter concrete pipes. Two sets of precast concrete headwalls guide the channel banks to the pipe barrels.

All crossings take the form of inverted syphons to ensure the required controlled flows can pass through the channel. Upstream and downstream rock beaching has been designed at each of the crossings to minimise erosion and scour around the structures.

11.5.4 Forest outlet regulators

Regulators are required at the outflow points of the forests to achieve the desired extent and duration of flooding. The design criteria for the main outlet regulators (G5 New and B13) are to:

- Contain managed watering flood inundation up to agreed level within forests.
- Pass agreed flows.
- Provide appropriate access to structure.
- Provide adequate erosion protection works.
- Proposed works to have no adverse effects on private property.
- G5 New: containment levee to be overtopped, initially via a dedicated spillway, during large flood events and debris to be managed.
- B13: provide designated spillway to allow controlled overtopping of road/levee for natural rainfall events producing inundation levels greater than 75.0 mAHD.
- Provide safe downstream passage for fish exiting the forest.

The regulating structures at G5 New and B13 will be manually operated dual leaf gate structures. Power supply will not be provided to these sites. Gate lifting will be undertaken manually with portable actuators. The structures will consist of concrete (precast) box culverts containing dual leaf gates. The regulator will ensure the controlled flow can be supplied and that the existing flood protection levels are maintained. Upstream and downstream rock beaching has been designed to minimise erosion and scour around the structure. The forest outfalls will consist of stepped sheet pile energy dissipater structures with rock fill. B13 will also include a spillway designed to overtop during large natural rainfall events at a maximum rate of 250 ML/d. It comprises 300 mm rip rap with a geotextile lining and 100 mm of filter material to prevent scour or erosion. Rip rap immediately upstream and downstream is also designed to assist with erosion protection. The spillway channel is 25 m long with a width of 6.7 m wide and 1.2 m deep and is rock lined along its entire length.

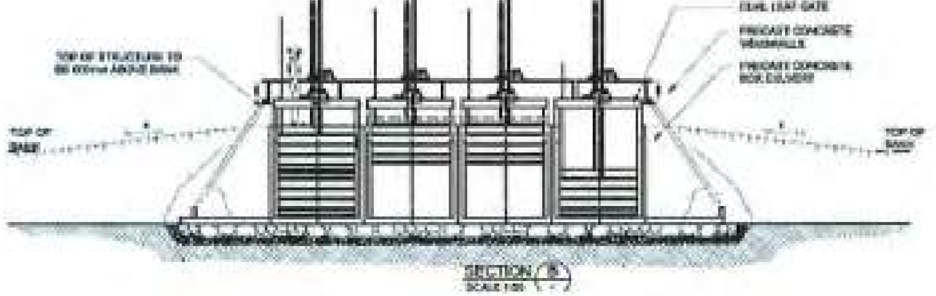


Figure 11-4: B13 Forest Outfall Regulator (URS 2014)

For the G5 New regulator, a permanent access track will provide access from the Guttrum Levee. To maintain managed flood inundations into Guttrum Forest a small weir is designed at 0.3 m below the crest of the access track at 75.8 mAHD to allow flow to enter the forest. The weir has a width of 7 m and is designed to overtop during large flooding events. It comprises 300 mm rip rap with a geotextile lining and 100 mm of filter material to prevent scour or erosion. Rip rap immediately upstream and downstream is also designed to assist with erosion protection.

The B7 outflow regulator is a smaller structure crossing an existing channel that will consist of one concrete (precast) box culvert 1.4m wide and 1.4m high containing a dual leaf gate. The regulator will ensure 50ML/d controlled flow can be supplied and ensuring the existing flood protection levels are maintained. During a greater flood event the structure can be topped. Permanent access to regulator is provided by an existing Benwell Forest track which will cross the existing channel. Downstream rock beaching from the structure to the Murray River has been designed to minimise erosion and scour around the structure and channel. The forest outfall will consist of a stepped sheet pile energy dissipating structure with rock fill.

Estimated costs for the structures are provided in Section 13 with further detail in the *Concept Design Report*.

11.5.5 Forest levee options

Both forests have extensive perimeter levee systems built to protect adjacent private land from inundation during large natural flood events (greater than the 26,000 ML/day River Murray flows mimicked by this project). These levees were constructed by local landholders and (anecdotally) have never failed. However, to minimise the potential risk of private land inundation resulting from managed flooding, a series of options based on the level of risk were identified and costed (Water Technology 2014).

The choices available for structural levee works are:

- Replacement of all active sections of levees
- Replacement of all levees with a High Consequence regardless of Likelihood and all High Risk Points of Weakness
- Replacement of sections of levees considered to be of High Risk
- Upgrade/Repair levees considered to be of Moderate Risk

The works identified are informed by the *North Central CMA Levee Breach Risk Assessment and Strategy Report* (Water Technology 2014). To best manage the risk of third party flooding, the preferred works option is to replace all levees with a 'High Consequence' regardless of likelihood, and all 'High Risk Points of Weakness'.

With the replacement of all high consequence lengths of levee along with high risk locations, the majority of medium risk locations are also addressed. Minimal additional repair work would be required on the remaining medium risk locations, providing a cost-effective method of achieving the desired outcome of reducing the overall risks to low (Water Technology 2014).

In addition to structural levee repair, at project construction, the levees to be retained will be inspected by an experienced engineer and arborist. All vegetation will be removed from the levee and its immediate surrounds, either side of the toe of the levee, where in the professional opinion the risk to the levee will be reduced by its removal. This

Benwell Forest south levee (Photo: DHI)

process would potentially result in further minor points of weakness being identified and rectified where necessary.

Ongoing inspections and maintenance will be conducted to prevent inappropriate vegetation growth and the ongoing condition of the levee monitored and repaired where necessary. With ongoing inspections and maintenance, this low risk profile is considered manageable.

Three levee options were designed with high and low estimates to account for the highly variable nature associated with levee construction costs and design standards (outlined below). In addition to the forest perimeter levee options, a levee will be required in Benwell Forest to contain water on the floodplain (B13 levee).

Figure 11-5: Proposed Benwell Forest perimeter levees for construction and maintenance

Table 11-5: Guttrum and Benwell Forests – Levee key parameters

Parameter	Guttrum perimeter	Benwell perimeter	B13
Length (m)	1,415	3,300	1035
Height (mAHD)	76.50	75.60	75.40
Width at crest (m)	6	4	4

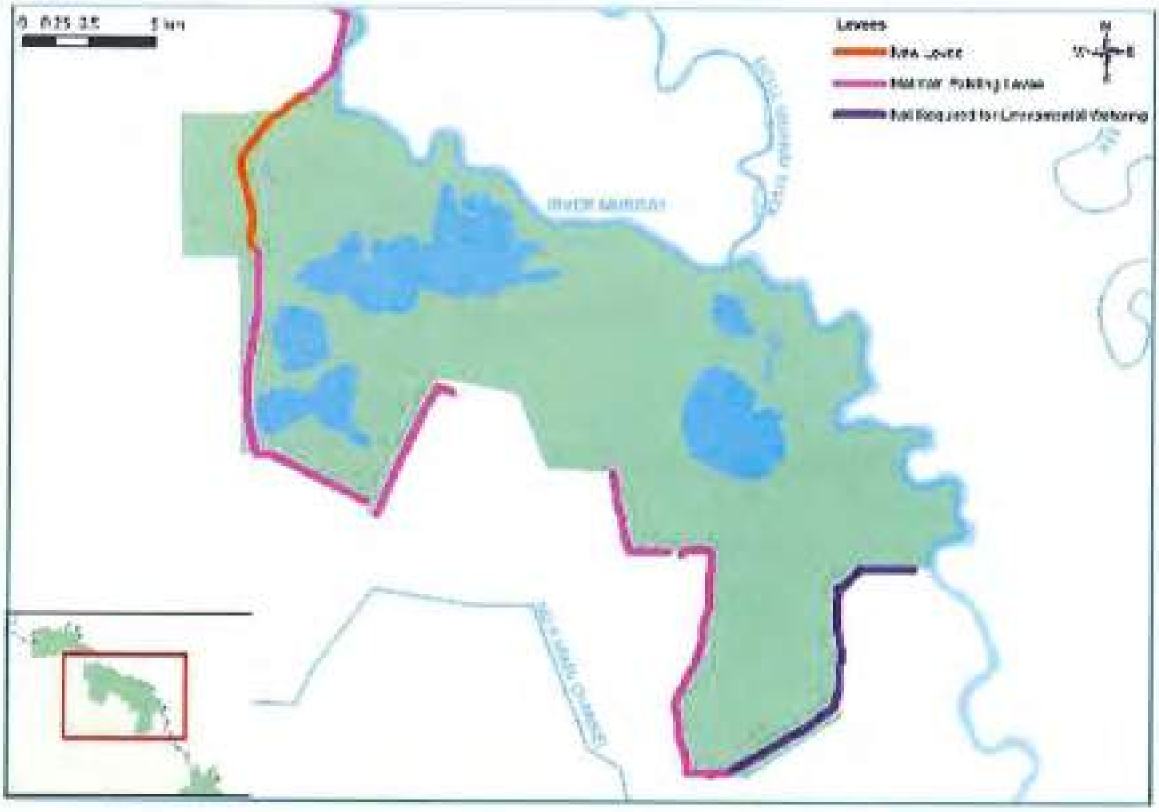


Figure 11-6: Proposed Guttrum Forest perimeter levees for construction and maintenance

Option 1 – High Risk and High Consequence sections

This option represents a low cost estimate of undertaking work on the existing perimeter levees only (no replacement of existing levees). Works would target repair to locations of high and extreme risk. The associated upgrade costs and design criteria were adopted from the *Levee Breach Risk Assessment and Strategy Report* (Water Technology 2014).

There are no locations along the levee with medium risk addressed. This option is not considered suitable for management of risk associated with environmental watering activities.

Option 2 – Levee constructed utilising existing track

Two separate designs were developed for Option 2, a Lower Cost estimation and a Higher Cost Estimation. Typical cross-sections of these two designs are shown in Figure 11-7. The Option 2 High Estimate cost was recommended for adoption in calculating the capital costs (Cummins 2014) by the Expert Review Panel (refer to Section 13 for cost estimates).

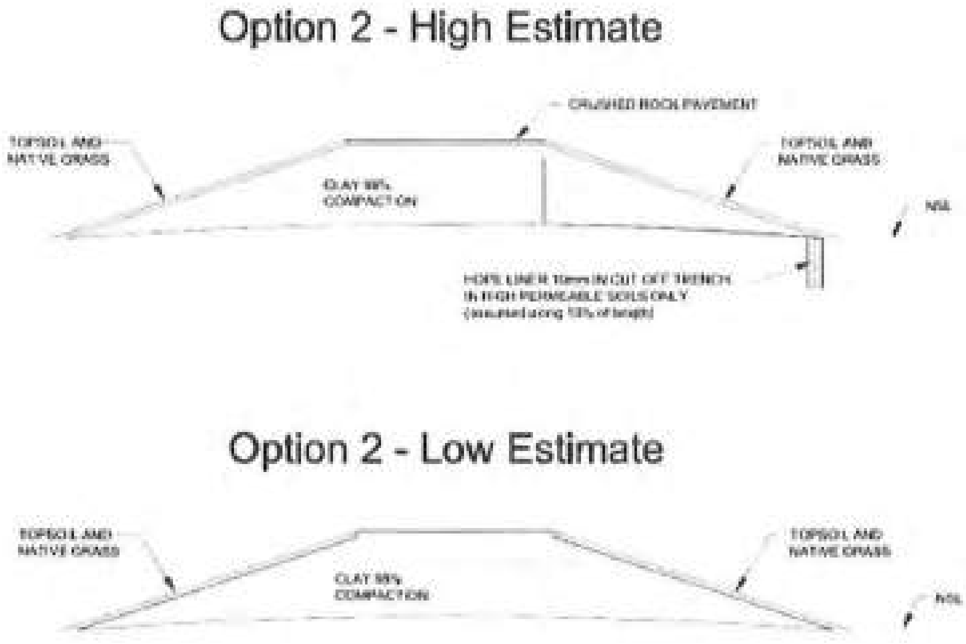


Figure 11-7: Guttrum and Benwell Forests – Option 2 High and Low Cost Estimate Designs (URS 2014)

Option 3 – Levee constructed with excavation of track material

Two separate designs were developed for Option 3, a Lower Cost estimation and a Higher Cost Estimation. Typical cross-sections of these two designs are shown in Figure 11-8. The Expert Review Panel recommended that the Option 3 levees were unduly conservative.

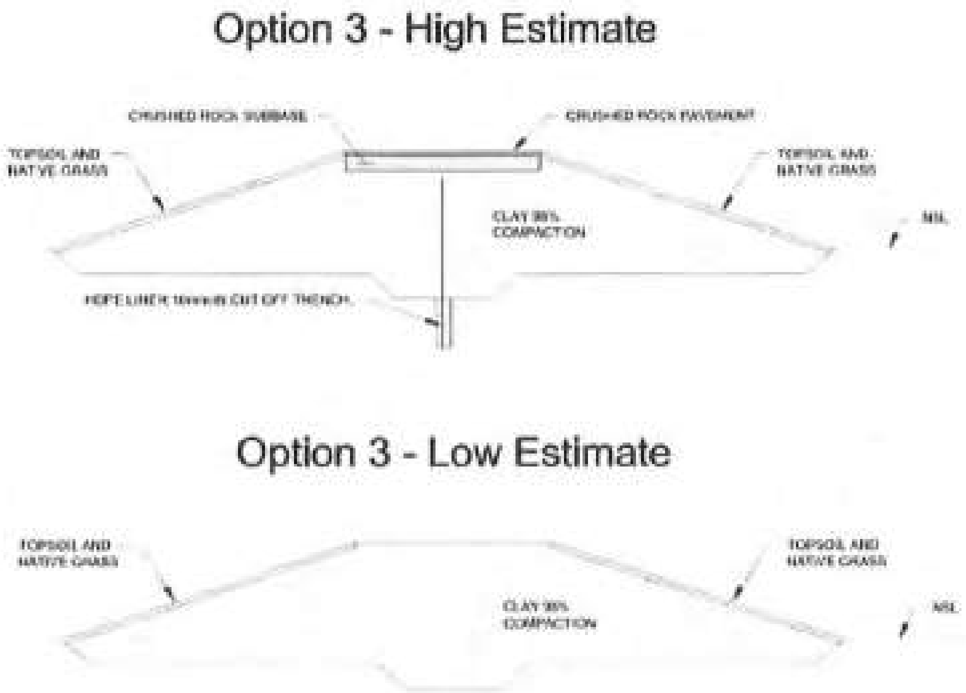


Figure 11-8: Guttrum and Benwell Forests – Option 3 High and Low Cost Estimate Designs (URS 2014)

Assumptions and exclusions

The following assumptions and exclusions were made with regard to the levee upgrade works.

- No provision has been made for levee maintenance access tracks.
- Construction footprint to include the width of the levee (including batters) plus 5 m on either side for the entire length of levee.

Criteria and functionality

The following criteria and functionality have formed the basis for the concept design associated with the levee works for Options 2 and 3 as outlined above.

- New levees to be located adjacent to existing levee and preliminarily along existing vehicle access tracks/road alignments (path of least disturbance).
- Access track dimensions on levee crest to be consistent with Parks Victoria access track design and maintenance guidelines (DSE 2011).
- Safe batter slopes to be considered.
- Levee/Road drainage cross-drainage to be considered.
- Levee to have 3:1 (H:V) batter slopes.
- Levee materials to be clay (98% compaction) and 100 mm of top soil and native grass covering on all batter slopes. The high estimates will also include 100 mm crushed rock pavement along top width of levee. Additionally, the Option 3 high estimates perimeter levees will have a 300 mm crushed rock sub base along their top width.
- A 0.5 m deep, 1 m wide catch drain along both sides of the levee to reduce water pooling against the levees which will direct water to cross culverts located at low points along the levee alignment. Flap gates have been included to ensure water can only flow one way.
- For the high estimates, a levee cut-off feature to reduce the risk of piping failure. The cut-off comprises a 10 mm HDPE liner the length of the levee. Option 2 would have this system used in highly permeable soils only (which was assumed to be 10% of the levee length). Option 3 would have this system through the entire length of the levees.
- Low estimates have a reduced allowance for tree removal, haulage and levee material costs. No purchase of topsoil included in costs, and no cut off trench with HDPE liner.
- For the Barmah Forest levees (perimeter and B13), passing lanes will be provided approximately every 200 m where there is a clear line of sight. Where forward view is obstructed, distance between passing lanes to be 100 m or less as appropriate. These have been incorporated into the design in order to allow vehicles to be able to pass without having to drive onto the batters which could cause erosion and degradation of the levee. The passing lanes have been designed as 30 m long and 2 m wide. This will mean that the total width of the track will be 6 m at these locations which should be adequate for two vehicles to pass.
- Spill points at four separate locations have been incorporated into the design of the B13 forest containment levee track raising upgrade. These have been designed as 20 m long localised low points within the levee alignment in order to control water flow over the levee in a staged manner during extreme natural rainfall event. The spill points have been designed to have a sill level of 75.20 mAHD (200 mm lower than the crest of the levee). They will be rock lined to limit the amount of potential

erosion of the levee and will transition from the levee crest at shallow 1:20 (H:V) in order to limit the disruption to vehicles using the track.

11.5.6 Reed Bed Swamp connection

Works are required to enable pumping of water from the River Murray into the Reed Bed Swamp complex and to facilitate connectivity between Reed Bed and Little Reed Bed swamps.

There are three key elements to these works:

- A pump stand to allow water to be pumped to these locations from the River Murray.
- Expansion of the channel into Reed Bed Swamp to enhance flows.
- Works to enhance connectivity across the forest floor between the wetlands.

The design features are to:

- Provide 5 ML/day from the River Murray to Reed Bed Swamp and Little Reed Bed Swamp.
- Provide temporary diesel pump to transfer water from River Murray to existing flood runner channel.
- Provide pump hardstand suitable for temporary pump.
- Provide two new stop board control structures, one at the outlet to Reed Bed Swamp and the other at the outlet to Little Reed Bed Swamp.
- Provide 150 m long access tracks from existing access track to each stop board control structure.

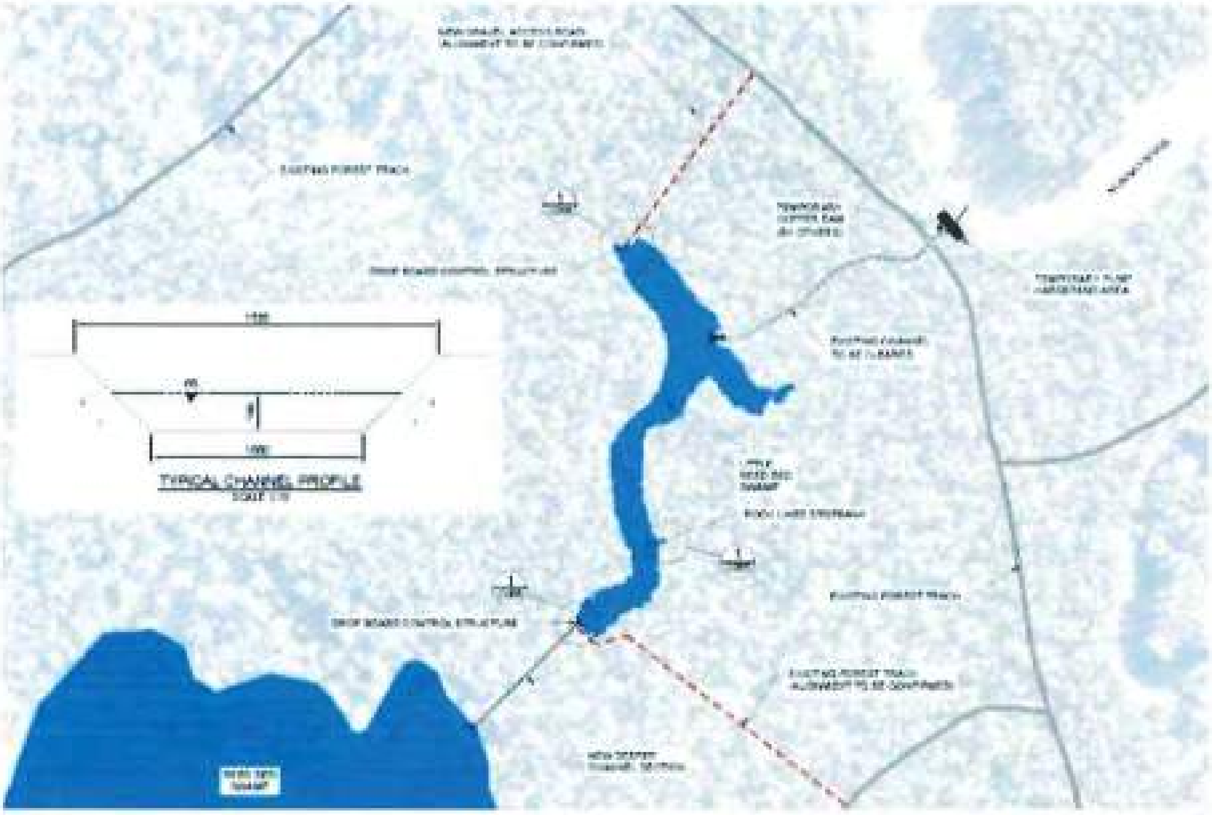


Figure 11-9: Connectivity between Reed Bed Swamp and Little Reed Bed Swamp (URS 2014)

Estimated costs for these works are provided in Section 13 with further detail in the *Concept Design Report*.

11.5.7 Ancillary works

A number of complementary ancillary works have been identified to enhance the effectiveness of environmental watering events. In addition, ancillary works have been identified to assist with maintenance of existing perimeter levees. It should be noted that cost allowance estimates only have been developed. No design and only limited on site verification of these works has been undertaken.

The ancillary works include both specific site works and standard ancillary components common to a number of sites:

- New levee access tracks along private property and within the forest for existing perimeter levee monitoring and maintenance where water touches/pools against the existing levee.
- G5 Old erosion protection works to protect the existing bridge, channel and outfall at G5 Old during a natural flood event or high river the flows with erosion protection.
- Top up low points in existing levee system in order to provide the required level of service as well as maintain a minimum of 200 mm freeboard. This option adopted the recommendations from the *Levee Breach Risk Assessment and Strategy Report* (Water Technology 2014), which determined low points and points of weakness along the levee alignment. Total lengths of levee needing raised were adopted from the report.
- Water level monitoring devices.

Estimated costs for these works are provided in Section 13 with further detail in the *Concept Design Report*.

11.5.8 Private land acquisitions

Project implementation will require acquisition of private land on three properties for the construction of irrigation channels into the forests. The intent is to conduct a voluntary land acquisition process as for TLM *Gunbower Forest – Flooding for Life* project.

A structured engagement process with the three landholders and risk mitigation strategy was developed:

- Acquisition plans were developed by GMW. These identified the preferred channel location and the required alignment and area extent.
- Initial discussions with the affected landholders were conducted by North Central CMA in collaboration with GMW. Secondary options were prepared for alternate channel alignments.
- In-principle agreement to conduct further negotiations was received from all land owners.
- Follow up valuations were undertaken to provide cost estimates.

Indicative costs are provided in Section **Error! Reference source not found.**.

11.6 Reliance on other measures or actions

Interdependencies and complementary actions are detailed in Section 12. However, this project is not reliant on other supply or constraint measures for implementation or operation.

11.7 Geotechnical investigations

Geotechnical investigations have been conducted to inform the detailed design phase. Preliminary results were provided 19 December 2014 with completion in January 2015. Results of these investigations will be utilised to refine the designs.

In the absence of geotechnical results, the concept designs for the G1, G2 and B1 offtake regulators and the G5 new and B13 outlet gates incorporate extensive sheet-piling which adds approximately [redacted] to the construction cost estimate. Depending upon the outcome of the geotechnical investigations, cost estimates for the regulators may be reduced.

The key objectives of the geotechnical investigations are to provide:

- Geotechnical information at the locations of important infrastructure to assist in progressing the concept designs. The following will be undertaken:
  - Assessment of the presence or otherwise of poor quality materials (e.g. silts and softened soils) and requirements for preparation of suitable foundations for regulating structures, culverts, levees.
  - Requirements for cut-offs of filtering if needed.
  - Design of stable earthfill structures and slopes for new embankments, levees and channels.
  - Assessment of suitability of the excavated materials for re-use in the constructed works.
  - Impact on groundwater on the proposed works and requirements (if needed) for managing groundwater.
- Baseline geotechnical information to assist understanding of the subsurface conditions and importantly to reduce the potential for latent condition claims related to the ground conditions and groundwater.

All proposed infrastructure sites will have borehole drilling and/or test pitting undertaken. Soil samples will be analysed at a laboratory accredited to the National Association of Testing Authorities.

11.8 Ongoing operation, maintenance and management of infrastructure

Refer to Section 14 which outlines the process being undertaken in Victoria to determine asset ownership, management, operation, and maintenance. Once determined, it will be possible to develop an asset operations and management plan, risk management framework, water accounting arrangements, and ongoing operational monitoring and record keeping arrangements.

12 Complementary Actions and Interdependencies

The proposed *Guttrum and Benwell Forests Environmental Works Project* supply measure will affect the Victorian Murray (SS2) surface water SDL water resource unit. This SDL resource unit is anticipated to be affected by this supply measure through an adjustment to the SDL, pending MDBA confirmation of a final off-set amount.

12.1 Interdependencies

Any potential interdependencies for this supply measure and its associated SDL resource unit, in terms of other measures, cannot be formally ascertained at this time. This is because such interdependencies will be influenced by other factors that may be operating in connection with this site, 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 all likely linkages and inter-dependencies for this measure and its associated SDL resource unit, particularly with any constraints measures, will 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 supply measure and its SDL resource unit cannot be completed until the MDBA models the full adjustment package and Basin governments agree to a final package.

12.2 Complementary actions

To maximise on the environmental outcomes from implementation of the supply measure, a number of complementary actions have been identified.

12.2.1 Invasive plants and animals

Invasive plants and animals threaten biodiversity by competing for natural resources and contributing to habitat and native species loss and displacement. Invasive plants often displace native species and can provide harbour for invasive animals. Invasive animals such as foxes directly prey on native fauna, and have been identified as a significant threat to freshwater turtle populations. The *North Central CMA Invasive Plants and Animals Strategy* (IPA Strategy) identified Guttrum and Benwell Forests as supporting key priority asset animals, such as the Carpet Python and Grey Crowned Babbler. The North Central CMA has developed the *Guttrum and Benwell Forests Key Asset Project* under the IPA Strategy; however implementation is subject to funding. The project identifies a number of other animals for protection including the EPBC-listed Growling Grass Frog and Australasian Bittern. Activities that would enhance the achievement of the majority of the ecological objectives include:

- Invasive Animal Management: monitor pest animal activity (e.g. European Fox, Rabbit and Feral Pig) and employ appropriate management techniques (e.g. baiting, fumigation)
- Invasive Plant Control: target high threat weeds (e.g. Weeds of National Significance: - Bridal Creeper, Paterson's Curse, African Boxthorn, Blackberry, Bathurst Burr, Prickly Pear) particularly weed infested areas.

12.2.2 Revegetation

A number of understorey species that would normally be expected in these forests are absent (Biosis 2014b). The *Guttrum and Benwell Forests Key Asset Project* identifies strategic revegetation of some species to assist in improving the forests' floristic diversity. This would enhance ecological objectives S2 and S3- the semi-permanent wetland objectives relating to vegetation condition and plant functional groups (refer Section 4).

12.2.3 Management of grazing

Grazing licences currently exist in the Guttrum and Benwell Forests. Unrestricted grazing can risk the achievement of the ecological objectives S2 and S3, particularly if grazing occurs during germination, growth, flowering or seed setting times. However grazing can also provide some benefits, for example, short-duration, intense, livestock grazing can help to open up a dense indigenous grass ground layer, which can allow the establishment of many indigenous herbs and forbs (DEPI, 2013). An assessment of the risk of grazing to achieving the ecological objectives using DEPI's 'Managing grazing on riparian land: Decision support tool and guidelines' (the Guidelines) could inform:

- Negotiations to place special conditions on grazing licences with licensees to manage the timing of grazing (e.g. after native vegetation has set seed), reduce stocking intensity or exclusion of high risk areas
- Strategic fencing: the *Guttrum and Benwell Forests Key Asset Project* identifies fencing areas prone to high disturbance from recreational vehicles and cattle grazing as a primary activity. The Guidelines would inform assessment of specific sites.

12.2.4 River Red Gum encroachment

The investigation of potential options for ecological thinning in areas already affected by River Red Gum encroachment is an activity in the *Guttrum and Benwell Forests Key Asset Project* and would enhance the achievement of ecological objective S4- absence of River Red Gum encroachment. DEPI is also considering a program of active intervention to remove invasive River Red Gum that has encroached on wetland areas. This could be incorporated into a Forest Coupe Plan for timber harvesting in the Guttrum and Benwell Forests.

12.2.5 Cultural heritage protection

Aboriginal cultural heritage sites are known throughout the forests. Complementary actions could include works to isolate and protect areas of cultural heritage value and minimise incidental damage from forest users and/or disturbance.

12.2.6 Aboriginal engagement

North Central CMA is undertaking project work with the Guttrum and Benwell Forest's Traditional Owners to progress the development of meaningful cultural flow objectives including:

- Project management of a Barapa Cultural Flows project
- Co-ordination of a Project Steering Committee
- Co-ordination of a Barapa Culture Team to undertake field investigations
- Development of a framework to develop cultural flow objectives
- Promoting understanding of the cultural values to forest stakeholders and the broader community
- Communication to stakeholders of project learnings
- Improving annual watering priorities to incorporate social, cultural and spiritual values

The North Central CMA employs an Indigenous Facilitator to share knowledge with Barapa Barapa Traditional Owners and Aboriginal groups aimed to:

- Increase opportunities for Indigenous partnerships in Living Murray icon site planning, activities and monitoring
- Provide communication and updates on Living Murray and North Central CMA activities
- Promote the involvement and sustainable use of Aboriginal groups in natural resources.

This process has included ongoing investigation of opportunities for economic and cultural benefit from the provision of cultural services, such as tourism. Guttrum Forest has been identified as a potential priority natural asset to utilise in this endeavour for its rich cultural landscape and proximity to the existing tourist market.

12.2.7 Tourism

Environmental watering has the potential to expand the tourism industry and create jobs, boost the local economy and raise the profile of the Guttrum and Benwell Forests. This is a priority for the Gannawarra Shire Council (Gannawarra Shire Council Plan, 2013).

The Gannawarra Shire Council is committed to the delivery of a sustainable future for its communities, with targeted maintenance, enhancement, management and promotion of environmental assets, such as the Guttrum and Benwell Forests, to assist in the delivery of environmental, economic and social outcomes. The Council has been proactive in establishing a framework for activity and investment in the environment through the adoption of its *Economic Development Strategy 2011-15* and *Environmental Sustainability Strategy 2013-16* that advocate and promote the eco-tourism market. Bird watching, bush walking and canoe trails would be tourism opportunities arising from the environmental watering of the Guttrum and Benwell Forests.

13 Costs, Benefits and Funding Arrangements

13.1 Overview

This section of the Business Case details the estimated financial costs of the Project, separated into the following key Project areas and components:

- Detailed design: design and approval
- Capital costs
  - Construction: on-ground water delivery infrastructure works and capital asset items
  - Risk management: costs incurred to minimise potential risks from the operation of the project
  - Contingency: the uncertainty around construction costs
- Operation and maintenance
- Co-contributions
- Project benefits: benefits and costs that support a compelling case for investment.

This business case presents the cost to fully deliver the Project (i.e. until all infrastructure is constructed, commissioned and operational), including contingencies. *Cost estimates for all components in this proposal are based on current costs, with no calculation of cost escalations either accounting for the time taken from estimating the cost to the time for construction to commence or for escalation during execution of the Project.*

To ensure sufficient funding will be available to deliver the Project in the event that it is approved by the MDB Ministerial Council for inclusion in its approved SDL Adjustment Package to be submitted to the MDBA by 30 June 2016, cost escalations will be determined in an agreed manner between the proponent and the investor as part of negotiating an investment agreement for this project.

13.2 Total capital costs

Although significant work has been undertaken to develop cost estimates, including peer and expert panel review, information gaps, uncertainties and options remain. Further investigation in the next phase of the Project will provide greater certainty for refinement of the costs. Cost estimates are presented as a range to reflect uncertainties for the current stage of development. During the detailed design phase as the designs are refined and contingency reduced costs may decrease.

The total capital cost estimate to design, construct and commission the works at Guttrum and Benwell Forests (excluding GST) is **$28,449,309** (at the upper cost estimate of levee Option 2) (see Table 13-1).

Table 13-1: Guttrum and Benwell Forests – Estimated capital costs

[redacted]

Across the upper and lower cost estimates, costs for items relating to quantities, task duration and rates are unchanged, except as noted below.

Table 13-2: Guttrum and Benwell Forests – Key Allowances relating to Estimated Costs

[redacted]

13.2.1 Assumptions

The following assumptions were made during the preparation of the construction cost estimates:

- Rates for items mentioned in the cost estimates are based on locally available material
- It is assumed that earthworks are carried out in the dry season
- Geotechnical investigation and analysis have not been estimated in the cost estimates provided (as they are to be undertaken during the current stage)
- Tree cutting at each site is based on desk top analysis and engineering judgement from available aerial photographs
- Top soil cannot be used as backfill material
- Backfilling of soil includes a 10% bulking factor
- Given that many of the structures have no existing road access, mobilisation and demobilisation, costs have been included with each individual structure.

Costs associated with further geotechnical investigations have been included in the detailed design costs.

13.2.2 Exclusions

Construction contract costs do not include the following:

- GST
- Allowances for detailed design, investigations, superintendence, project management and construction support
- Obtaining (planning) approvals and permits
- Native vegetation offsets
- Cultural heritage and environmental studies
- Preparation of maintenance programs and operations manuals
- Landowner consultation and land acquisition (except as specified)
- Disposal of contaminated material to an approved site
- Testing and commissioning of regulators and fishways.

The costs listed are included in the detailed design and construction ancillary costs.

13.3 Detailed design and approvals

The cost estimate (excluding GST) for completion of the detailed design and approvals phase for the Project is **$3,227,474**. This includes the completion of technical investigations, detailed design of all structures, and statutory approvals. below is a summary of the cost estimates.

Management of the detailed designs will take 18 months and be supported by the North Central CMA, DEPI and Parks Victoria for the following key activities:

- Investigations
  - Further geotechnical investigations, hydraulic modelling and field inspections, land feature and level surveys, to refine designs
  - Water delivery cost arrangements
  - Irrigation system capacity review
  - Flood risk assessment – survey restrictions (e.g. culverts) and hydraulic modelling (overland flow path)
- Statutory approvals – includes preparation of permit applications, referrals and assessment (refer to Section 15 for the list of regulatory approvals anticipated for the Project)
- Ongoing stakeholder engagement and communications
- Resolution of delivery costs
- Development of the construction proposal.

Table 13-3: Guttrum and Benwell Forests –Costs associated with the detailed design phase

[redacted]

13.4 Construction costs

A detailed construction cost estimate is provided in the *Concept Design Report*. Table 13-4 below is a summary. Only forward looking costs have been included.

The total capital construction cost estimate is **$8,125,449** for the higher cost estimate.

The concept designs for the G1, G2 and B1 offtake regulators and the G5 new, B7 and B13 outlet gates incorporate extensive sheet-piling as they have been developed in the absence of geotechnical information and to ensure erosion on the banks of the River Murray is prevented.. This sheet-piling adds approximately [redacted] to the construction cost estimate. Geotechnical investigations are currently underway to inform the detailed design phase. Depending upon the outcome of these investigations, due for completion in early 2015, cost estimates for the regulators may decrease.

Table 13-4: Guttrum and Benwell Forests – Estimated construction costs for works

[redacted]

[redacted]

13.4.1 Ancillary Costs

The estimated ancillary costs for construction and commissioning are provided in the following table. Project delivery will be a partnership between the North Central CMA, the constructing authority (TBC), DEPI and Parks Victoria. The cost estimate is [redacted] for the higher cost estimation (including Levee Option 2).

Table 13-5: Guttrum and Benwell Forests – Estimated ancillary costs for construction and commissioning

[redacted]

13.4.2 Risk Management

The risks to the Project development and delivery are explained in Section 17**Error! Reference source not found.**, risk r egister in Appendix 4 and in the Project's *Risk Management Strategy*. Costs have been estimated for flooding delays, wet weather delays, approvals delay and contingency.

Flooding delay

An assessment has been made by URS (URS, 2014) on the potential cost impact at each of the sites if they are inundated by a 1 in 2 year frequency river flow event, during the construction period (see Table 13-6). The cost allowance for flood risk totals between [redacted] for the higher cost estimation.

For regulator and irrigation works a three month construction period has been assumed. For levee systems, a six month construction period has been assumed. The intention is to build these structures during the dry period of each year.

The cost of rework and clean up of the site following a flood is assessed as follows.

- A greater than 20,000 ML/d flow based on Torrumbarry Weir records occurs on average once every two years
- This represents a 50% chance of it occurring in any one year at any time as the records did not show a bias towards one seasonal period compared to another
- The construction cost (excluding contingency and profit) of the component of the works at risk is determined and divided by the construction period
- It is assessed that the site would be out of action and or being reinstated over a 2 week period following the event. (1 week for the event to recede, 1 week to reinstate)
- Therefore the cost of the flood event is two weeks of cash flow for the site
- The probability of this occurring is 50% hence the contingency allowance is the two week cost multiplied by 0.5
- This is then expressed as a % of the raw construction cost (excluding profit and contingency).

An example of the flood risk for B11 Levee Option 3 is as follows

[redacted]

Table 13-5: Gunbower and Benwell Forests – Flood risk contingency cost allowance estimate

[redacted]

[redacted]

Wet weather delay

A 3% allowance for wet weather delay is included in the contingency costs. This contingency will be transferred to the construction contractor, with as stated relief on the basis of time extensions at no extra cost. Due to the remote access and the difficulty in getting materials to site, most work will be done in the dry period and potentially programmed over a number of seasons. This will reduce the risk of wet weather delay. 3% is allocated for wet weather delay.

Approvals delay

The *Regulatory Approvals Strategy* (DEPI 2014) has identified the approvals, permits or licences likely to be required prior to the commencement of construction (Appendix 7). The Strategy includes an indicative program for effecting regulatory approvals that predicts a minimum 31 week period to obtain all required approvals. However, delays can come from a number of sources including:

- Delays in preparing applications including supporting documentation
- Delay in assessment of submissions by agencies
- Request by agencies for further studies/investigations/specific management plans creating a time delay;
- Lack of direction with regards to policy or change in policy
- The project triggers an EES or assessed as a controlled action under the *EPBC Act* (1999).

No construction work will be tendered until all approvals have been granted, or will be staggered at different sites depending on expected timeframes and ease of obtaining for approvals. Based on experience from TLM program, and advice from GMW and URS, a 20% contingency has been included on top of the existing approvals cost estimate of [redacted] is estimated for approvals delay.

Project contingency

Contingency as applied in an engineering cost estimate is defined as the cost assigned to uncertainties in the definition of the project. The major sources of uncertainty that have influenced the degree of contingency include:

- Insufficient geology and geotechnical information, i.e. upon later investigation geological conditions found to be worse than reasonably anticipated during concept design
- Design changes, including changes in the level of design definition, i.e. as more detailed hydrology, topography and site conditions become available alterations to the design criteria for a given regulator structure result in larger capacity requirements
- Quantity variations include potential changes initiated by design alterations or site conditions
- Variation in site conditions, including unanticipated permit restrictions, seasonal limitations or environmental conditions
- Price variations including escalations, and variations in labour rate and commodity prices
- Schedule risks, include unforseen delays due to weather affects i.e. projects with seasonal window restrictions are particularly vulnerable to schedule delay risks since relatively short delays can result in having to move construction windows to the following season.

A 40% contingency has been applied to the design given the level of uncertainty. A lower 20% contingency was also considered. However, with a 20% contingency, there are no allowances for changes in design. The degree of contingency will reduce over time as further investigations, planning and detailed designs are completed during the Project implementation phase. Contingency costs are outlined below.

Table 13-7: Guttrum and Benwell Forests – Estimated contingency costs

[redacted]

Construction cost estimates specific for specific infrastructure is presented in the *Concept Design Report*.

Perimeter levees

As discussed in Section 11, three separate levee options were designed with Lower Cost estimations and Higher Cost estimations to account for the highly variable nature associated with levee construction costs and design standards:

- Option 1 – Addressing Locations in existing perimeter levee of High and Extreme Risk Only
- Option 2 – Construct new levee directly on top of existing track
- Option 3 – Construct new levee with excavation of track material

The construction costs estimated for the forest levees are provided in the *Concept Design Report*. Only levee Option 2 has been represented here in the main body of the business case. Further detail relating to levee Options 1 and 3 is available in the concept design costings. The total cost estimates for levee Option 2 are shown in the table below.

Table 13-6: Guttrum and Benwell Forests – Total estimated construction cost estimates for levee upgrades

[redacted]

The following assumptions and exclusions were made with regard to the levee upgrade works but costs are included elsewhere:

- No provision has been made for levee maintenance access tracks; and
- Construction footprint to include the width of the levee (including batters) plus 5 m on either side for the entire length of levee.

13.5 Ongoing operating and maintenance costs

Asset renewal costs have not been included in the calculation of operation and maintenance costs.

The following table confirms the projected costs (in current dollars) for system operation and maintenance. These do not form part of the construction budget but are to be considered in future budget planning.

Table 13-7: Guttrum and Benwell Forests – Ongoing estimated costs after practical completion

[redacted]

13.6 Co-contributions

No co-contributions are provided for project capital costs.

13.7 Proposed financial responsibility for ongoing costs

The Department of Environment and Primary Industries (DEPI) convened a workshop with the key delivery partners for Victoria's proposed supply measures to inform a decision on proposed financial responsibility for ongoing asset ownership costs. Attendees at the workshop included representatives from the Mallee and North Central CMAs, DEPI, Parks Victoria and Goulburn Murray Water. The workshop identifed a set of criteria required by an agency to own, operate and maintain an asset like those proposed by this supply measure. These were:

- Access to capability to perform the required functions, either directly or under contract;
- Access to suitable resources which can be deployed in a timely, efficient manner;
- Sufficient powers conferred under legislation to enable services to be provided;
- Demonstrable benefit or linkage to primary business mission or activities;
- Ability to collaborate and co-ordinate effectively with multiple parties; and
- Risks are allocated to those best placed to manage them.

Although the criteria have been identified, the delegation of asset ownership and operation, including any associated proposed financial responsibility, cannot be formally ascertained at this time. Such decisions are generally whole-of-Victorian Government, and sufficient information is not currently available to enable a formal position on this matter to be clarified.

In line with good financial practice, any long-term arrangements for asset ownership, operation and maintenance should maximise cost-efficiencies where they can be found. This includes options to 'package up' ongoing ownership, operation and maintenance where this is deemed the most cost-effective approach.

DEPI will be in a position to provide more formal advice on the state's preferred long-term arrangements for this supply measure once the full suite of Victorian proposals under the SDL adjustment mechanism has been more definitely scoped. This is anticipated to occur during the course of 2015, pending receipt of advice from the MDBA on likely adjustment.

13.8 Cost benefit analysis

The primary purpose of the *Guttrum and Benwell Environmental Works Project* is to achieve environmental benefits and water efficiencies (refer to Section 4). However, the delivery of this project will provide other benefits that depend on the condition of the forests, such as supporting social and cultural values.

A formal cost benefit analysis has not been undertaken as part of this business case, because the main benefit of the project (the SDL adjustment) cannot be reliably estimated at this stage in the planning cycle. This approach is consistent with the guidance given on page 26 of the Phase 2 *Assessment Guidelines for Supply and Constraint Measure Business Cases.*

However, from a qualitative perspective, Victoria considers that, on balance, the benefits of this project will significantly outweigh its costs. The rationale for this assertion is that a broad range of enduring social, economic and environmental benefits can be assumed to arise from this project.

These include:

- the social and economic benefits that will accrue for local and regional communities and businesses associated with the construction and operation of the project;
- the increased social and environmental amenity at this site arising from improved environmental health, increasing its attraction for tourism and recreational activities; and
- the broader regional economic benefit of taking less water out of productive use as a consequence of undertaking this project and being credited with an SDL Offset.

These immediate benefits can also be assumed to have a range of flow-on effects. For example, the investment committed to construction of the Project will benefit local businesses and families through jobs, materials purchase and normal everyday expenditure. A similar positive impact can be anticipated as a consequence of the increase in tourism and recreation generated by the project and its environmental amenity dividend over its lifetime.

Specific examples of the anticipated benefits are described in more detail below.

13.8.1 Recreation and tourism

The Guttrum and Benwell Forests provide a valuable regional recreational amenity that supports a mix of activities including:

- Over 30 bush camping sites throughout both forests, where campers undertake: swimming, canoeing, horse riding and fishing in the waters of the River Murray
- Motorcycling, four wheel driving and pleasure driving
- Nature study (e.g. bird watching) will be enhanced through environmental watering, attracting more visitors to the area. An example of this is the recent sighting of the Long-billed Dowitcher (*Limnodromus scolopaceus*) at Lake Tutchewop which has attracted bird watchers from all over Australia
- Hunting: the Game Management Authority was established on 1 July 2014 to regulate game hunting in Victoria. Hunting generates significant social and economic benefits for the regional community. A recent study estimated the regional expenditure that can be attributed to hunting for game and pest animals (in this area that is mainly duck and feral pig) (RMCG 2014). The report concluded that $10.4 million was spent on hunting in the Gannawarra Local Government Area in 2013 and that 73 jobs could be attributed to this expenditure.

13.8.2 Cultural heritage

Traditionally, Indigenous people have a strong affinity with waterways and wetlands, as a vital source for food, water and camping. Guttrum and Benwell Forests are part of the lands of the Barapa Barapa people. The cultural heritage sites are an important component of the forest values. Improved flooding will result in the enhancement of the ecological values of the site, with the opportunity to maximize on cultural flows if relevant, in the future.

13.8.3 Licensed forest use

There are a number of licences that give holders the right to use the forests' resources for a range of activities. This includes grazing of cattle, timber harvesting and apiary production.

The bee hives in the Guttrum and Benwell Forests depend on seasonal flowering of River Red Gums, which will increase in regularity and reliability due to the Project. This should provide opportunities to increase the number of active sites and hives at each site.

River Red Gum timber harvesting forms an important part of the economic value of the Guttrum and Benwell Forests. The proposed watering will enhance the value of the available timber. An economic assessment of the likely benefits of additional watering for the timber sector was undertaken as part of the VEAC River Red Gum Forests Investigation. This identified a 26% increase in value from the greater growth of timber as a result of environmental watering at a whole of northern Victorian scale (Gillespie Economics 2008). There is no quantified figure available for the current volume of timber extracted from these forests but Guttrum and Benwell Forests are increasingly valuable for this resource given that timber harvesting is now prohibited in Gunbower National Park.

13.8.4 Economic Benefit to local communities

Previous analysis by Dyack *et al* (2007) has calculated the economic value of additional visitation days to the Barmah Forest based on the travel cost method. Given the proximity and similarities between the Barmah Forest and Guttrum and Benwell Forests, this is a useful source study for transferring values to the current site. Dyack et al found that each additional day of visitation had an economic value of $135.50 per day. Adjusting for CPI from 2007 to 2014 produces a current value of $161.80 per day.

Applying this economic value to the number of visitor days to the forests, as estimated by Parks Victoria, gives a total economic value of visitation as per Table 13-8.

Table 13-8: Annual visitor days to Guttrum and Benwell Forests

Type	Visitor days*	Economic value per day**	Value
Over night	5,000	$161.80	$809,000
Day visitors	2,500	$161.80	$404,500
Total	**7,500**	$161.80	**$1,213,500**

*B Wehner (Parks Victoria), pers comm., October 2014

**Tourism Research Australia, *Regional Tourism Profile for Central Murray 2012/13*

13.8.5 Balancing benefits and dis-benefits

There will be some dis-benefits from the proposed Project, but these are expected to be minor and transient. Construction will involve some physical disturbance which has the potential to impact on native vegetation and wildlife. These impacts will be minimised by careful planning and adherence to relevant state and Commonwealth legislation, regulations and guidelines. Any unavoidable impacts will be minimised through the implementation of an environmental management framework during construction.

Access will also be restricted to some extent during the construction phase, but this will be temporary. Given the relative remoteness of the site from populated areas, there is unlikely to be any significant loss of social amenity to surrounding communities.

Access to the forests will also be restricted during managed flooding events. This will impact on recreational activities and licence holders. Management of this dis-benefit is further discussed in Section 10.2. It is noted however that this restriction on access would also occur during natural floods.

Over the long term, the local and regional communities near the forests will significantly benefit from the environmental amenity generated.

13.9 Project Seeking Commonwealth Funding

Victoria will be seeking 100 per cent of project funding for this supply measure proposal from the Commonwealth. The funding requested will ensure the proposed supply measure is construction ready, built in accordance with all regulatory approval requirements and conditions, and fully commissioned once construction is completed.

14 Stakeholder management strategy

The *North Central CMA SDL Offset Projects Stakeholder Management* Strategy (the Strategy) was prepared to guide engagement and communication activities for the *Guttrum and Benwell Forests Environmental Works Project*. The Strategy clarifies project specific communication and engagement objectives, key messages and target audiences to ensure clear, transparent and thorough communication to all identified stakeholders.

An overview of the Strategy and the outcomes from the business case phase is provided in the following sections.

The North Central CMA uses the International Association for Public Participation's (IAP2) spectrum for effective engagement in strategic planning. The spectrum guides the approach to identifying activities at the project level that will see interaction with community members and stakeholders in ways that inform, consult, involve, collaborate and ultimately empower them (North Central CMA 2013).

14.1 Project phases

Four phases have been identified for the Project's engagement with stakeholders. These are:

- Phase 1: Business case development
- Phase 2: Approvals and detailed design
- Phase 3: Construction
- Phase 4: Operation

The various phases of the Project will ensure there is appropriate and relevant approaches to engagement with stakeholders. There will be inevitable overlap as the Project moves into different phases, but activities will generally be adapted to suit the particular phase of the Project and the needs of key stakeholders.

14.2 Key stakeholders

The proposed supply measure has engaged a similar 'community of interest' to The Living Murray *Gunbower Forest – Flooding for Life* project. The North Central CMA has been able to draw on the extensive consultation and engagement activities undertaken for that project and experience gained. These existing channels of communication, and the benefits of prior significant work to assess issues and develop effective solutions, have provided a solid basis for the development and implementation of the Strategy for this project.

Stakeholders have been characterised into four groups relating to their interest and influence on the project outcomes (see

Table 14-1). Relative to each other, Stakeholder Group 1 has a higher level of interest in, and influence on, the project outcomes, with Stakeholder Group 4 having the lowest level. More detailed information on the Project stakeholders is provided in the Strategy.

Table 14-1: Stakeholders of the Guttrum and Benwell Forests Environmental Works Project

Stakeholder group	Stakeholder
Group 1: Project partners (Collaborate)	1. DEPI 2. GMW 3. Parks Victoria 4. Commonwealth Department of the Environment 5. MDBA 6. Commonwealth Environmental Water Holder (CEWH) 7. VEWH
Group 2 (Involve)	1. Irrigators / Adjacent freehold landholders (Diversion, Gravity and Groundwater) • GMW customers • Torrumbarry Water Services Committee (a GMW Committee) 2. Traditional Owners: Barapa Barapa 3. North Central CMA Community Committees: Portfolio Group, Natural Resource management Committee (NRMC)
Group 3 (Consult)	1. Local Government: Gannawarra Shire Council 2. Local community: townships of Koondrook and Murrabit 3. Environmental / Technical Expert organisations: Murray Darling Freshwater Research Centre, Murray Darling Association, Environment Victoria, Australian Conservation Foundation, Murray-Darling Freshwater Research Centre, Victorian National Parks Association • Community groups: Cohuna and District Historical Society, Cohuna and District Progress Association • Industry (businesses and services): timber industry, tourism businesses, licence holders (firewood, apiary, grazing) • Special Interest Groups: Field and Game Australia, Victorian Farmers Federation, angling clubs, VR Fish, Heritage Victoria
Group 4 (inform)	1. Recreational users: campers, fishing and boating users, 4WD motorist, field and game hunting enthusiasts, day visitors, eco-tourists, bush walkers, bird watchers, trail bike riders, horse riders, domestic firewood users 2. Wider community: local retailers, North Central CMA region, Victoria, Murray Darling Basin 3. Local schools

The aims and approaches for engaging with each of key stakeholders were identified to ensure that each stakeholder's expectations and needs were met. These approaches (summarised below) have been applied consistently for all engagement and communication activities during the business case phase. They will form the basis for future phases of the Project but will be adapted to reflect the activities and needs of a particular phase.

Stakeholder Group 1: Collaborate- involves an extended level of consultation to formulate solutions and requires a targeted and tailored approach to meet the needs of each individual stakeholder.

Stakeholder Group 2: Involve- aims to ensure that issues and concerns are understood and are considered as part of the process. It involves working directly with stakeholders and informing them in a timely manner of any planned works or major decisions related to the project. E.g.

Stakeholder Group 3: Consult- aims to increase understanding and awareness through sourcing feedback on analysis, alternatives or decisions. It is more generic in nature in comparison to Stakeholder Group 1.

Stakeholder Group 4: Inform- stakeholders are informed about the project and/or decisions that have already been made through a variety of mediums that may include information dissemination and responding to enquiries.

14.3 Phase 1 stakeholder group engagement

A stakeholder reference group (project partners) was established and existing groups utilised for community consultation.

North Central CMA groups: Engagement with the local community has been achieved through established groups such as the North Central CMA Board, North Central CMA Natural Resource Management Committee (NRMC), the Barapa Barapa Steering Committee, and the Gannawarra Shire Council. Field trips and presentations have been used to connect with these groups and disseminate information to the local community about the project.

Stakeholder Reference Group (SRG): this group was established to provide a forum for inter-agency collaboration to facilitate the successful development and implementation of Project. The success of the Project depends on the support and involvement of the various agencies – DEPI, Parks Victoria, Goulburn Murray Water (GMW) and Gannawarra Shire Council. These organisations have been involved, throughout the project, through representation on the project's SRG. Local staff have provided key information to support the development of concept designs, operating scenarios and risk assessments. Staff have also reviewed concept designs and their comprehensive knowledge of the forest ecology and flooding patterns has been invaluable in the development of the package of works.

Adjacent Landholders: Letters were sent to all 17 landholders adjacent to the project site in February 2014. Over June-August 2014, North Central CMA contacted 17 landholders and held face-to-face meetings with 13 who were interested in further discussion. That has ensured close, personal contact with key affected parties to explain the proposed project and understand landholders' concerns.

Traditional Owners: The traditional owners of Guttrum and Benwell Forests are the Barapa Barapa people. There is no Registered Aboriginal Party (RAP) covering the project area so, as a consequence, three Barapa Barapa groups were engaged: the Barapa Barapa Nations Aboriginal Corporation (BBNAC) are previous RAP applicants for the Activity Area; the Barapa Barapa Aboriginal Corporation (BBAC) represents native title applicants; and additional Barapa Barapa people residing in NSW were also consulted. Barapa Barapa Elders nominated field participants to undertake Aboriginal cultural heritage survey work based on their knowledge, experience and interest in Barapa country.

In accordance with the Victorian *Aboriginal Heritage Act* 2006, a Cultural Heritage Management Plan (CHMP) is being developed for the package of works. The Barapa Barapa people were engaged from inception of the CHMP (Table 14-2 below). This has ensured that the Indigenous stakeholders are fully informed and involved in the project.

Table 14-2: North Central CMA engagement with the Barapa Barapa people

Date	Event

Date	Event
May 2014	Project brief to a Barapa Barapa Steering Committee
June 2014	Consultation on drafting the RFQ and involvement in the tender assessments
June 2014	Provide comment/feedback on the Aboriginal Cultural Heritage desktop assessment
June 2014	Consulted about the Notice of Intent to prepare a Cultural Heritage Management Plan
July 2014	Inception meeting and field visit
July 2014	Barapa Barapa members participate in surveying for cultural heritage material
September 2014	Post survey meeting with Barapa Barapa Steering Committee and provide comment/feedback on the standard survey report

The development of the CHMP will be used as the key vehicle for ongoing engagement with the Barapa Barapa people. With assistance from the North Central CMA Indigenous Facilitator, written and face-to-face briefings, phone conversations and site tours will continue to be used to maintain open communication channels with the Barapa Barapa people.

Licence holders: North Central CMA conducted face-to-face meetings with licence holders in the Guttrum and Benwell Forests. This included holders of grazing licences and Gannawarra Shire Council, which holds an extractive licence. Letters were sent to other commercial forest users (i.e. honey production and commercial timber harvesting) informing them about the Project.

Public Information: FAQs, fact sheets, a media release, introductory letters to licence holders, an introductory email to other project stakeholders, and project update emails have been prepared and released. A project page is available on the North Central CMA website. The fact sheets were attached to letters and emails introducing/explaining the projects and their progress, displayed at the North Central CMA office, attached to the project page on the North Central CMA website, and provided at a stand at the Murrabit Markets on 4 October 2014.

Stakeholder engagement and communication activities undertaken to date are shown inTable 14-3.

Table 14-3: Stakeholder engagement and communication activities undertaken

Date	Event	Target Audience
February 2014	Project introductory letters	Landholders with property adjoining project sites
April 2014	Project update presentation and field visit	SRG
May 2014	Project update presentation and field visit	SRG
June-August 2014	One-on-One meetings	Landholders with property adjoining project sites
July 2014	Project update presentation and field visit	SRG
July 2014	Project update presentation	CRG
July 2014	Council meeting	Gannawarra Shire councillors
August 2014	Project update email	Landholders with property adjoining project sites
August 2014	Project update presentation and field visit	SRG
August 2014	Field visit	North Central CMA NRMC
August 2014	Project update presentation and field visit	CRG
September	Project introductory email	Stakeholder groups

2014		
September 2014	Project update presentation and field visit	SRG
October 2014	Project update email	Landholders and Stakeholder groups
October 2014	Project introductory letters	Licensees (apiary, timber harvesting, tourism operators)
October 2014	A project information stall at the Elmore Field Days	Community members and industry
October 2014	A project information stall at the Murrabit Markets	Community members
October 2014	Project update presentation	North Central CMA NRMC
October 2014	Presentation to Torrumbarry Water Services Committee	Irrigators' committee

Public information stall at Murrabit Markets (Photo: G. Smith)

14.4 Outcomes

The main outcomes from stakeholder engagement for Phase 1 are provided in Table 14-4. For all activities undertaken, the North Central CMA has documented the: consultation parties; the type and degree of impact; the extent of support for the project; and how consultation outcomes have been considered and responded to by the North Central CMA.

In summary a wide spectrum of groups and individuals, with differing levels of interest and impact, were engaged. The main findings that demonstrate broad community support are:

1 There is recognition of the importance of the health of the forest for environmental, social and economic values

2 There is broad support to increase the frequency of flooding as this is considered the best way to restore and enhance forest health

3 There is recognition that the Project will increase the health and vitality of the Guttrum and Benwell Forests and so support social and economic uses as well as ecosystem health.

Some concerns and interests raised by the community, through engagement activities, are outlined below. These have been addressed through the risk assessment process.

- Unplanned Inundation: risk of flooding to inundate private land. The risk management sections confirm the comprehensive program in place to reduce risks to an overall rating of "Low".
- Blackwater: risks of blackwater entering and affecting water quality in the River Murray. The operating regim is designed to minimize this risk. Increasing the watering frequency should also reduce the build-up of organic material that can feed such events.
- Access: reduced access for recreation, timber harvesting, grazing and honey production. There will be restricted but overall benefits are recognized.
- Fire: risk of greater understorey growth increasing wildfire risk. There was also an acknowledgment that greater inundation will reduce the frequency and severity of such risks.

ference Group (S g) eetings DI appointed staff egarding roles and	management plans, access management • Water resource manager- irrigation infrastructure usage and capacity modelling	• Comprehensive involvement by project partners in project development • Project ownership shared between the project partners and North Central CMA • Large level of trust between project partners and North Central CMA to formulate options and solutions	• Roles and responsibilities clearly defined • Investigation results reviewed independently and deeme for purpose' • North Central CMA sought direct advice and innovation i formulating solutions and incorporating advice and recommendations into the decisions to the maximum ext possible
-face) briefing site visits landholder project and meetings (face to acted by North Central	• Directly affected landholders – construction works, access tracks on their properties, or acquisition of land for irrigation channels to water the forests • Traditional Owners – potential impact on cultural sites, potential changes to cultural values	• Recognition of the importance of the health of the forests for environmental and economic values. • Support to increase the health and vitality of the forests • Increase the frequency of flooding as this is considered the best way to restore and enhance forest health • Further engagement and awareness raising is required to dispel commonly held myths, including the impact of environmental water on irrigators' entitlements • Recognition that increased watering will involve some restriction in access to the forests • Common concerns – unplanned flooding, blackwater, limited access to forests, fire risk	• Work directly with stakeholders through project develop • Stakeholder issues and concerns understood and conside as part of the project development • Informing stakeholders in a timely manner of any planne works or major decisions related to the project • Meet stakeholder expectations and respond to their conc • Robust and rigorous investigative approach to ensure be environmental outcomes are achieved • Results of investigations available for review • Independent technical review of investigation results wit being deemed 'fit for purpose'
fing sessions letters to all license	• Licence holders - disturbance to stock grazing, commercial timber harvesting or apiculture practices • Industry / Special Interest Groups - economic opportunities reduced through limited access to forest during watering events		• Views of stakeholders sought that have contributed to influencing decisions • Informing stakeholders in a timely manner of any planne works or major decisions related to the project • Meet stakeholder expectations and respond to their conc • Robust and rigorous investigative approach to ensure be environmental outcomes are achieved • Results of investigations available for review • Independent technical review of investigation results wi being deemed 'fit for purpose'
d through the North e	• Limited access to forest during watering events	• Positive feedback through comments and email replies	• Stakeholders are informed about the project and/or deci that have already been made • Objective information provided which is of a high quality, consistent, timely, appropriately targeted and clearly and easily understood by the audience
e accessed on the website (fact sheets, rmation) essed through the website and social ter, Twitter, Facebook) ils	• Limited access to forest during watering events	N/A	N/A

14.5 Proposed consultation approaches for the implementation phase

Further engagement activities and implementation of the Strategy will continue in the next phases of the Project if it is approved. The cost of these engagement and communication activities is estimated at $129,258 (refer to Section 14 for detailed costings).

The Strategy will be updated and revised for subsequent phases. An overview of the proposed approach is provided in Table 14-5.

Table 14-5: Consultation strategy for implementation phase

Stakeholder group	Consultation approach	IAP2 level of engagement	Number / Timing
Group 1 Project partners	Intensive engagement through: • Steering Committee (6 weekly meetings) • Construction progress meetings	Collaborate	Ongoing
Group 2	Irrigator / Adjacent landholder meetings (face-to-face) Special events – site tours (e.g. funding announcement, commencement of construction)	Involve	Funding announcement/ commencement of construction 2016 Contact and organise meetings with all interested irrigators / adjacent landholders 2016 Site tours 2017
Group 3	Teleconference briefing sessions with North Central CMA	Consult	One during 2016
	Presentations conducted by North Central CMA	Consult	One during 2016
	Special events – site tours (e.g. funding announcement, commencement of construction)	Consult	Site tours 2017
Group 4	Information accessed through the North Central CMA website	Inform	Accessible in 2016
All stakeholders	Information package accessed on the North Central CMA website (fact sheets, photos, contact information)	Inform	Accessible in 2016 (as soon as possible after funding is confirmed)
	Project updates accessed through the North Central CMA website and social media (e.g. newsletter, Twitter, Facebook)	Inform	Regularly during 2016
	Project update emails	Inform	One during detailed design, two during construction, one associated with each watering event. Coincide with media releases
	Media communication (e.g. media releases, newspaper articles, radio interviews, television interviews)	Inform	Media releases – one during detailed design, two during construction, one associated with each watering event. Coincide with project update emails

15 Legal and statutory requirements

15.1 Regulatory approvals

A Regulatory Governance Group (RGG) is supporting the delivery of business case requirements by providing a mechanism, through high-level engagement with responsible agencies, to streamline the regulatory approvals process (see Section 15). The RGG provides advice to the Project Control Board (PCB) regarding the regulatory approvals needed for Victorian projects, the resolution of associated issues and the development of a program-level strategy to obtain approvals.

The term 'approvals' refers to all environmental and planning consents, endorsements and agreements required from government agencies by legislative or other statutory obligations to conduct works (DEPI 2014c). The approvals required for the *Guttrum and Benwell Environmental Works Project* are listed in

Table 15-1.

The *Regulatory Approvals Strategy* (DEPI 2014c) has identified the approvals, permits or licences likely to be required prior to the commencement of construction. An assessment of the likely impacts of the proposed works, based on preliminary construction footprints confirms the need to obtain a number of local government, State and Commonwealth approvals.

The following supporting documents will be required and are likely to be requested through referral decisions or planning permit conditions (DEPI 2014c):

- An offset strategy for native vegetation losses (see below)
- An environmental management framework
- A threatened species management plan, and
- A cultural heritage management plan.

Any vegetation losses will be offset in line with current state policy. A program-level approach to offsetting is currently being developed, where the primary offsetting mechanism will be the gains in vegetation condition within the areas watered by the various Victorian works-based supply measures. An assessment of vegetation offset requirements based on preliminary construction footprints indicates that the offsets for this proposed supply measure can be met using this approach.

The application process for each approval, the responsible agency, timing of submissions and timeframe for decisions are outlined in the *Regulatory Approvals Strategy* (DEPI 2014c). The Strategy includes an indicative program for effecting regulatory approvals that predicts a minimum 31-week period to obtain all required approvals. This timeframe assumes that an Environmental Effects Statement is not required, all applications (including supporting documentation) are already prepared and that there are no significant delays during the assessment process. The Strategy also notes that there are a number of linkages and dependencies between approvals, where for example, some approvals cannot be issued until another is approved e.g. a planning permit cannot be granted until there is an approved cultural heritage management plan.

Table 15-1: Regulatory approvals anticipated for Guttrum and Benwell Forests (DEPI 2014c)

Approvals required	Description
Commonwealth legislation	
Environmental Protection & Biodiversity Conservation Act 1999 • Referral	A number of potentially affected "matters of national environmental significance" (MNES) are present in the forests: • Migratory waterbird species (JAMBA, CAMBA, ROKAMBA) • Nationally threatened species or communities e.g. River Swamp Wallaby Grass (*Amphibromus fluitans*)
Victorian legislation	
Environmental Effects Act 1978 • Referral	Relevant to one of the six referral criteria for individual potential effects i.e. • Potential extensive or major effects on the health or biodiversity of aquatic, estuarine or marine ecosystems, over the long term
Planning & Environment Act 1987 • Planning permit • Public Land Managers Consent	Public land manager permission required to apply for a planning permit for works on public land Planning permit application is submitted with supporting documentation: e.g. offset strategy, 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 will 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
Crown Land Reserves Act • Consent	Approval for a public authority to carry out its functions on the Murray River Reserve
Flora & Fauna Guarantee Act 1988 • Protected flora licence or permit	Application for approval to remove protected flora within public land for non-commercial purposes. • To include targeted surveys for threatened/protected species considered likely to be present at the site and impacted by proposed works
New South Wales legislation	
NSW Environmental Planning and Assessment Act 1979 (EP&A Act) • Planning permit • Public Land Managers Consent	Permission from public land manager required to apply for a planning permit for works on public land Planning permit application submitted with supporting documentation e.g. offset strategy, threatened species management plan Local Council refers applications and plans to appropriate authorities for advice
Water Management Act 2000 (WM Act) • Works on waterways permit	Application for a licence to construct and operate works on a waterway
Crown Lands Act 1989 • Consent	Approval for a public authority to carry out its functions on the Crown land

15.2 Legislative and policy amendments and inter-jurisdictional agreements

At the state level, a legislative change may be needed to address the requirement to secure native vegetation offsets prior to clearing. As the primary offsetting mechanism is expected to be the gains in vegetation condition within the areas watered by the various Victorian works-based supply measures, i.e. the outcomes of the measures once operational, this requirement cannot be met. DEPI will investigate a suite of options to address this issue during the detailed design for this measure, including the potential for a planning scheme amendment. Note that the other options to be investigated do not require legislative changes.

Matters related to other regulatory approvals necessary for the implementation of this supply measure are discussed elsewhere in this business case.

No other amendments to state legislation or policy are anticipated. This includes any formal amendments to state water sharing frameworks, or river operations rules or practices.

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.

Victorian 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 or pattern of delivery.

15.3 Cultural heritage assessment

Initial assessments have been conducted both for Aboriginal and European cultural heritage. Parts of the forests are areas of cultural heritage sensitivity. The archaeological assemblage is characterised by a dominance of mounds/earth features with known burial sites, artifact scatters and scar trees recorded in the Aboriginal Cultural Heritage Register Information System (ACHRIS) database (GHD 2011). However, there are few, if any historic sites of significance for European heritage under *the Heritage Act 1995* (LRGM - Services 2014).

The North Central CMA has engaged the Traditional Owners, identified as the Barapa Barapa people, in the development of a Cultural Heritage Management Plan (CHMP), under the *Aboriginal Heritage Regulations 2007* (Part 2, Division 5).

Cultural heritage survey of forests (Photo: M. Barker)

16 Governance and project management

Appropriate governance and project management arrangements are in place to minimise risks to investors and other parties from the proposed supply measure. The sections below describe the governance arrangements during business case development and proposed arrangements during project implementation.

16.1 Governance arrangements during business case development

DEPI convened a Project Control Board (PCB) to oversee the development of business cases for the nine Victorian works-based supply measures. The PCB is comprised of senior executives from DEPI, the North Central and Mallee CMAs, GMW and Parks Victoria. This has ensured high level engagement of responsible agencies and has assisted in identifying and resolving program-level issues during development of business cases. The PCB's role has been to ensure that:

- All business cases meet the requirements set out in the Phase 2 Guidelines
- All business cases are of a high and consistent standard, and delivered within specified timelines
- The technical basis of each business case is robust, credible and fit for purpose
- That appropriate consultation with stakeholder agencies, affected persons and the community was carried out during business case development.

The PCB has been supported by an Expert Review Panel and Regulatory Governance Group, and project-specific governance arrangements set up by the North Central and Mallee CMAs (Figure 16-1).

Figure 16-1: Governance arrangements during business case development

The *Guttrum and Benwell Forests Environmental Works Project* business case has been endorsed by the PCB as part of the final package of Victorian business cases to be submitted for assessment under Phase 2 of the SDL adjustment mechanism.

16.1.1 Expert review panel

An Expert Review Panel (the Panel) was set up to examine the critical elements of each business case at key stages and assess quality, credibility and whether the element is fit for purpose. The Panel was chaired by David Dole and comprised of experts in engineering (including geotechnical, structural, hydraulic and water system operations), hydrology and ecology. Its members include:

- Phillip Cummins (engineering)
- Shane McGrath (engineering)
- Dr Chris Gippel (hydrology)
- Andrew Telfer (salinity)
- Professor Terry Hillman (ecology).

The following evaluations were carried out during the development of this business case:

- Engineering: Review of concept engineering designs (hydraulics and structures), the scoping of geotechnical investigations to support water management structure design and construction costs
- Hydrology: Review of hydrodynamic and hydrological models, data, modelled scenarios and outputs
- Salinity: review of assessments of potential salinity impacts of works and measures projects
- Ecology: Review of the descriptions of ecological values, the ecological objectives and targets, and environmental water requirements, and the descriptions of anticipated ecological outcomes and environmental water requirements

The expert review process has led to the conclusion that the underlying feasibility and outcome investigations have effectively provided a soundly based proposal that is fit for purpose. See Appendix 8 for the Expert Review Panel reports for this project.

16.1.2 Regulatory Governance Group

The Regulatory Governance Group (RGG) was established to support the delivery of business case requirements related to regulatory approvals. The RGG was comprised of relevant staff from Victorian approvals agencies, including DEPI, Parks Victoria and Aboriginal Affairs Victoria. The RGG provided advice to the PCB regarding the regulatory approvals needed for Victorian projects, the resolution of associated issues and to develop a program-level strategy to obtain approvals.

Setting up the RGG has provided a mechanism for high-level engagement with responsible agencies at an early stage to streamline the regulatory approvals process for proposed supply measures. While the RGG ceased operation when all business cases were finalised for submission (December 2014), the Group may be reconvened by the PCB as required.

16.1.3 Stakeholder Reference Group (Project Partners)

At the project level, development of the business case for the *Guttrum and Benwell Forests Environmental Works Project* was overseen by the Stakeholder Reference Group (North Central CMA 2014e). The group's role was to ensure the business cases developed for these sites are of a high quality, consistent standard, and that they meet the requirements of the Australian Government.

The Stakeholder Reference Group was comprised of members representing North Central CMA, Parks Victoria, Department of Environment and Primary Industries, Goulburn Murray Water, Murray-Darling Basin Authority, Department of Environment, Gannawarra Shire Council and Campaspe Shire Council (North Central CMA, 2014e).

Specifically the group was responsible for the following functions in the development and delivery of the relevant project business cases (North Central CMA, 2014e):

- Advising on the development and proposed delivery of the projects from a technical perspective
- Ensuring projects developed and the supporting business cases produced are technically rigorous and sound
- Guiding and advising on statutory and policy issues, including the identification of any constraints or issues that may impede the success of the projects
- Advising on interpretation of policy and legislation relevant to their agency
- Advising on processes to resolve issues relative to their agency
- Identifying any issues associated with the proposed works that may impact upon project implementation, including any policy changes
- Monitoring the development of business cases to ensure a consistent approach and that required information is provided, in accordance with the Phase 2 Guidelines.
- Disseminating information within their respective agencies regarding project progress and issues.

16.2 Governance arrangements during project implementation

To ensure that this proposed supply measure is delivered on time, arrangements will be put in place that ensure appropriate senior oversight of project governance and delivery. This will allow for the successful completion and operation of the measure as part of the SDL adjustment mechanism.

These arrangements will be predominantly based around those that were used to deliver the three Living Murray projects within Victoria, complemented with existing state government frameworks, which together will underpin a set of robust and thorough processes for procurement and project management. Key aspects of the proposed governance and project management for this supply measure are explained below.

16.2.1 Project management structure and team

The project management structure and team will be overseen by the project owner, currently anticipated to be the Department of Environment and Primary Industries (DEPI), Victoria. In line with the governance arrangements that have underpinned the Business Case preparation for this proposed supply measure, DEPI will be supported by a Project Control Board (PCB), comprised of senior executives from DEPI, the relevant Victorian Catchment Management Authorities (CMAs), the relevant constructing authority (e.g. Goulburn Murray Water, SA Water) and Parks Victoria.

It is expected that the PCB will be comprised of appropriate senior management representation from each of the participating agencies, who will have the required decision-making authority to oversee all elements of implementation. In line with the successful governance arrangements that were utilised during TLM EWMP and the outcomes of the workshop on ongoing asset management arrangements (see Section 4.10), the relevant constructing authority would be well placed to undertake the construction of the supply measure, supported by the relevant CMA.

16.2.2 Procurement strategy

As the primary delivery agency, the relevant constructing authority could manage procurement during the construction of the supply measure, operating under the high-level oversight of the PCB. Supporting this, North Central CMA will play a critical role by assisting in the development of a procurement strategy, which the PCB would approve. More specific details of the preferred approach for procurement will be detailed in the construction proposal.

16.2.3 Project Steering Committees or related governance mechanisms

In line with good governance practice, and again drawing on the experience of The Living Murray, it is expected that the PCB would meet regularly throughout the construction of this proposed supply measure to ensure that milestones and timelines are met, and to resolve any potential arising issues.

The PCB members would have the required decision-making authority to address any emerging risks, including the following:

- Identifying and resolving issues, including those that might impact timelines/budget.
- Providing guidance to resolve project-specific issues
- Ensuring appropriate consultation with key stakeholder agencies and the community
- Closely monitoring implementation to ensure timelines and budgets are met
- Making recommendations to DEPI on any issues that may arise during construction.

16.2.4 Monitoring and reporting during implementation

The PCB would be the key conduit for monitoring and reporting during the implementation of this proposed supply measure. This would include:

- North Central CMA providing regular implementation updates at each PCB meeting
- Consideration of any milestone or payment reporting that is likely to be required under all contractual funding arrangements associated with this supply measure.

16.2.5 Design and implementation plan with timelines

The PCB will meet regularly throughout the construction phase of this proposed supply measure to ensure milestones and timelines are met, to review designs, and to resolve any arising issues. North Central CMA will play a critical supporting role by assisting with statutory approvals and the development of the construction proposal, as well as managing discrete projects to support detailed designs and the implementation/ construction of the supply measure.

North Central CMA has a proven track record in the design and oversight of project delivery for major environmental works measures, such as TLM investment in the lower Gunbower Forest.

A detailed work plan will document the key tasks and the agency responsible, associated resources and timelines for the implementation of the supply measure. A timeframe for the completion of construction is shown in

Table 16-1.

Table 16-1: Milestones and timelines for construction

Stages	Yr 1	Yr 2	Yr 3	Yr 4
Planning/Detailed design				
Approvals				
Procurement				
Works				
Commissioning				

16.2.6 Reference Group

A Reference Group will be established to assist and advise on the commissioning and operation of this proposed supply measure. This group will provide a forum to involve project partners in the decision-making process, to consider broader system operations (e.g. of the River Murray and other environmental watering events) during planning and operations, and to inform stakeholders of operations and progress.

For the Guttrum and Benwell Forests site, the Reference Group membership will consist of partners and stakeholders, including the Murray Darling Basin Authority, the Victorian Department of Environment and Primary Industries, Goulburn Murray Water, NSW Office of Water, Lower Murray Water, Parks Victoria, the Commonwealth Environmental Water Holder and the Victorian Environmental Water Holder. Other agencies and organisations may be invited to participate as guests or observers.

The Reference Group's key responsibilities will be to ensure the necessary planning, monitoring, communication and reporting arrangements are established prior to and during events and to identify and monitor any event risks or issues. This allows for safe and effective operation of the works, real time response and adaptive management when necessary.

16.3 Governance expertise of partner agencies

Implementation of the project at Guttrum and Benwell Forests will be a partnership between four agencies: North Central CMA, DEPI, Parks Victoria and GMW.

16.3.1 North Central CMA

The North Central CMA's primary responsibility is to ensure that natural resources in the region are managed in an integrated and ecologically sustainable way. North Central CMA's work is based on rigorous science and delivered through meaningful partnerships with government agencies, industry, environmental organisations, private land managers, Indigenous stakeholders and the broader community. All delivery arrangements are formalised through a range of mechanisms including operating agreements, service level agreements and landholder incentive / tender management agreements, the application of comprehensive MERI frameworks; and the application and interpretation of complex spatial data.

The North Central CMA has a proven track record in successfully delivering a vast range of environmental projects which have varied in complexity, monetary value (up to multi-million dollar projects) and in spatial extent (from concentrated focal points to landscape-scale programs).

Operating within policies and controls approved and overseen by the North Central CMA Board ensures transparent and accountable governance systems that embody performance and continuous improvement. These governance arrangements include a quality management approach to project management, with policies and procedures for project management, contractual arrangements, procurement and risk management. The North Central CMA's risk management approach covers strategic, operational, financial and compliance risks.

The North Central CMA was recognised in 2014 by the Australian Organisational Excellence Foundation with a Bronze Award for its achievements utilising business excellence principles, thereby demonstrating a commitment to sustainable performance, stakeholder value, quality and service, philanthropic ideals, ethical behaviour and environmental sustainability.

16.3.2 DEPI

DEPI's primary responsibility in regard to this project is to act as its sponsor through the project assessment process established by the Intergovernmental Agreement on Murray-Darling Basin Water Reform 2014 (IGA). As part of this process, DEPI will represent the State of Victoria in negotiations with Commonwealth Government agencies to secure funding for the project, consistent with the commitments and arrangements outlined in the above mentioned IGA.

Once a funding agreement is reached for this project, DEPI will then assume an oversight role for the rollout of the project consistent with the terms of the funding agreement. As indicated previously, this oversight will be applied through the establishment of a PCB for the purposes of this project and any others that secure Commonwealth Government funding. It is envisaged that DEPI will chair and operate this PCB. Its primary focus will be to ensure that milestones and timelines are met and where necessary, to resolve any emerging issues that present a material risk to the conduct and/or completion of this project.

Over the past decade, DEPI has had considerable experience in undertaking such oversight roles to a high standard for major Commonwealth funded water infrastructure projects in Victoria. Notable examples in this regard include TLM Environmental Works and Measures projects at Gunbower, Hattah Lakes, Mulcra and Lindsay Islands, the GMW Connections Program and the Lake Mokoan project.

16.3.3 Parks Victoria

Parks Victoria is a statutory authority, created by the *Parks Victoria Act 1998* and reporting to the Minister for Environment and Climate Change.

Parks Victoria is responsible for managing an expanding and diverse estate covering more than 4 million hectares, or about 17 per cent, of Victoria.

Parks Victoria is committed to delivering works on the ground across Victoria's parks network to protect and enhance park values. Parks Victoria's primary responsibility is to ensure parks are healthy and resilient for current and future generations and to manage parks in the context of their surrounding landscape and in partnership with Traditional Owners.

Parks Victoria works in partnership with other government and non-government organisations and community groups such as the Department of Environment and Primary Industries, catchment management authorities, private land owners, friends groups, volunteers, licensed tour operators, lessees, research institutes and the broader community.

Healthy Parks Healthy People is at the core of everything Parks Victoria does. Parks and nature are an important part of improving and maintaining health, both for individuals and the community. Parks Victoria has a clear role to play in connecting people and communities with parks.

16.3.4 GMW

GMW provides rural water and drainage services in northern Victoria. GMW is the Victorian State Constructing Authority (SCA) for the MDBA, and the Victorian Murray Resource Manager, with responsibilities for water accounting and liaison with the MDBA on planned and actual diversion operations. GMW manages $4 billion of its own assets and a further $2 billion of MDBA assets to fulfil its functions. As SCA, GMW was the delivery authority for the Gunbower and Hattah TLM projects in Victoria. GMW has the asset management and design and construction policies and controls in place to deliver against a large capital works program. These policies and controls will direct GMW's activities for the delivery of each of the SDL Offset projects.

17 Risk assessment of project development and construction

The Project's approach to assessing risks has been outlined briefly in Section 7 and is further detailed in the *Risk Assessment Methodology* at Appendix 3 and the *Risk Register* at Appendix 4.

Section 6 deals with potential adverse ecological impacts and Section 10 with potential adverse social and economic impacts, from operation of the measure. This section reviews the potential risks related to the successful completion of the Project, including its construction and delivery. There is some inevitable overlap with the earlier risk assessment sections.

17.1 Construction risks

Construction of the infrastructure required to deliver the watering activities has the potential to have impacts. These include adverse environmental impacts, fire, damage to cultural heritage and/or European historical assets, injury or loss of life, and socio-economic impacts including disruption to local amenities or economic activities. Table 17-1 provides a listing of the risks which scored an overall risk rating of either 'Very High' or 'High'.

17.2 Process

Risk mitigation and management of construction activities involve a standard set of well-established legislated controls outlined below:

- The project proponent applies for a planning permit to undertake the works
- The application triggers referrals to multiple agencies
- The agencies impose conditions on the planning permit
- That permit requires the development and implementation of standard controls including:
  - Public Land Manager or Land Owner consent
  - Environmental Management Framework
  - Offset Strategy
  - Threatened Species Management Plan
  - Cultural Heritage Management Plan (see below)
  - Installation and site plans
  - Traffic Management Plan
  - Fire Management Plan
  - OH&S Plan
  - Rehabilitation Plan
  - Construction Management Plan
- The relevant construction contractor is responsible for developing and implementing these plans, subject to over-sight by the relevant managing authority.

Approvals under other legislation (refer Section 14.5) will be required as part of the development and delivery of the Project. The implementation of these legislated mitigation controls will reduce the risks in Table 17-1 to a 'Moderate' rating.

Table 17-1. Construction risks

Risks	Initial risk			Residual risk		
	Likelihood	Consequence	Rating	Likelihood	Consequence	Rating
Machinery may start a fire, causing loss of biodiversity and human and/or property damage.	Possible	Extreme Harm	Very High	Unlikely	Major Harm	High
Construction activities may cause injury to workers or community members	Unlikely	Major Harm	High	Unlikely	Moderate Harm	Moderate
Construction machinery or vehicles may be involved in traffic incidents or accidents, causing injury and damages.	Unlikely	Major Harm	High	Unlikely	Moderate Harm	Moderate
Relevant landholders are not engaged and supportive then project unable to acquire land required for channel supply	Possible	Major Harm	High	Unlikely	Moderate Harm	Moderate
Flooding of work areas through abnormal weather may prevent access causing delays	Possible	Major Harm	High	Possible	Minor Harm	Moderate
Poor quality control compromise the functionality and durability of the infrastructure	Possible	Major Harm	High	Unlikely	Moderate Harm	Moderate
Lack of available levee material with practical distance	Possible	Major Harm	High	Unlikely	Moderate Harm	Moderate
Bushfire impact on construction site	Unlikely	Major Harm	High	Unlikely	Moderate Harm	Moderate
Approval delays	Possible	Major Harm	High	Unlikely	Moderate Harm	Moderate
Change in staff lead to delays in project due to loss of corporate knowledge	Possible	Major Harm	High	Unlikely	Moderate Harm	Moderate

Further detail on the risks and associated mitigation controls is provided below.

17.2.1 Environment

To identify potential risks of construction to significant, threatened or listed species or communities of environmental significance, a flora and fauna assessment of proposed work sites was undertaken (Biosis 2014). The study identified the following matters listed under relevant legislation:

- *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) – potential habitat for EPBC-listed species (River Swamp Wallaby-grass and Winged Peppercress). It was considered that the proposed construction works would not have a significant impact on these species. The need for permit/approval is subject to further survey.
- Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act) – study recorded presence of Wavy Marshwort, Grey-crowned Babbler and habitat for a number of listed species. Numerous protected flora species were recorded.

The results of this assessment were incorporated into the Project design and options investigated to retain as much of the mapped vegetation/habitats as possible. Priority was given to the highest value areas and retaining as many large trees as possible.

In terms of the preferred option for the location of infrastructure, the delivery of environmental water from irrigation supply, as opposed to delivery from the River Murray, was preferable. This is because the irrigation supply options are located in an existing disturbed landscape and there is a lower likelihood of impacts to significant species and their habitat (Biosis 2014). The consequences of indirect or accidental impacts during construction would be less significant in the agricultural landscape as opposed to the native forests on the River Murray (i.e. accidental chemical spill, sedimentation event) (Biosis 2014).

As a result of the above investigation, the design and construction of the required infrastructure will minimise removal of native vegetation and terrestrial and aquatic habitat. i.e. the construction focused adverse ecological impacts are negligible.

In addition, the following will be undertaken by North Central CMA prior to any works:

- Prepare a referral to the Commonwealth Environment Minister to determine if the project needs to be formally assessed under the *EPBC Act* 1999 for potential impacts to Matters of National Environmental Significance (MNES).
- Prepare a referral under the *Environment Effects Act 1978* to determine if the project needs to be formally assessed.
- Prepare an offset strategy to meet the required offsets for the permitted clearance of native vegetation and threatened species habitat.
- Obtain permits required by policy and legislation.
- Prepare relevant management plans such as a Construction Environment Management Plan (CEMP) and a Threatened Species Management Plan (TSMP) that will identify activities required during construction to avoid or minimise impacts on significant, threatened or listed species or communities of environmental significance.

17.2.2 Fire

Fire has a residual risk rating of high due to the consequences of a fire e.g. property damage, loss of life. The likelihood of the event is considered to be 'Unlikely', but the consequence of any such event would still be 'Major Harm' and so triggers a Category B 'High' risk rating.

17.2.3 Physical Injury

The residual risk for physical injury, from construction vehicles and construction activities, is considered to be moderate. A Construction Management Plan will be developed that will prescribe responsibilities under the *Occupational Health and Safety Act 1994* to ensure safe practices for all activities on site and related to the construction work.

17.2.4 Community unsupportive

Community support is an important part of implementing and operating environmental watering projects. The North Central CMA has developed the *Stakeholder Management Strategy* (North Central CMA 2013) to guide engagement activities for the Project and mitigate the potential risks associated with a lack of community support. This is reported on in more detail in Section 14. Targeted engagement of adjacent landholders has been a key activity for the business case development phase of the Project. Also, land acquisition discussions for relevant landholders have commenced with initial feedback being very positive (see below).

Landholder acquisition discussions:

- Acquisition plans were developed by GMW. These identified the preferred location and the required alignment and extent
- Negotiation with the affected landholders was then conducted by GMW with assistance from North Central CMA. Alternative options were prepared.
- In-principle agreement to negotiate land acquisition was received.

The residual risk for this risk is considered to be moderate. Ongoing engagement and communication activities will be critical to ensure this risk is mitigated.

17.2.5 Flooding of work/Wet weather delays

If flooding of work areas or abnormal weather conditions prevent access to the site this could result in delays and costs for de-mobilisation and re-mobilisation of workforce. Ensuring appropriate contractor contract and management arrangements will be critical to ensure that cost escalation, insurance considerations and liability are agreed to up front. With this mitigation control on place the residual risk was assessed as 'possible' and 'minor' generating an overall risk rating of 'Minor'. Costs for this risk have been accounted for the in the construction costs (refer Section 13.2.1). The residual risk is considered to be moderate.

17.2.6 Poor workmanship

If poor quality controls are in place, the functionality and durability of the infrastructure will be compromised, impacting on the desired operational outcomes, future maintenance and operational costs and safety. The detailed design process will engage suitably qualified and experienced personnel, with a peer review process to ensure that appropriate quality assurance and quality controls are in place. The residual risk is considered to be moderate with a probability of 'unlikely'.

17.2.7 Cultural heritage

Construction of the works and operation of the proposed watering regime have the potential to impact on sites of cultural heritage significance. The proposed construction works in Guttrum and Benwell Forests will require the preparation of a Cultural Heritage Management Plan (CHMP) for indigenous cultural heritage as they are high impact activities within an area of Cultural Heritage Sensitivity as defined under *the Aboriginal Heritage Act (2006)* (Kaskadanis et al. 2014).

The CHMP will be the primary mitigation control to protect cultural heritage values from harm during construction. The CHMP will set out the actions required to minimise potential impacts and manage any residual risks. The major mitigation strategy will be to relocate works and activities away from locations with an existing record of significance. This will reduce both the likelihood and severity of any risk. However, it is recognised that the register of aboriginal sites and artifacts is only a partial record of all potential sites. Therefore, any work activities will also need to include systems to identify assets and respond to them as construction is undertaken.

The North Central CMA has an existing relationship with the Traditional Owners, the Barapa Barapa people, through its indigenous facilitator and project staff. The preliminary cultural heritage assessment was undertaken with Barapa Barapa Traditional Owners (Kaskadanis et al. 2014). If significant assets are identified during construction, the CMA will work closely with Barapa Barapa Traditional Owners to reach an agreed response, as well as adhering to the legal requirements. It is also worth noting that the Traditional Owners place considerable value on the health of the wetlands and forests.

A preliminary European cultural heritage study (Kaufman & Ballinger 2014) identified a number of cultural heritage sites of local significance. The preliminary study concluded that proposed works in Benwell Forest have potential to impact on the Benwell Floodgates. This is an archaeological site with legislative protection under Part 6 of the *Heritage Act 1995* and has been assessed as of sufficient cultural heritage significance to recommend to the Heritage Overlay of the Gannawarra Planning Scheme. Action will be required to ensure that this site is adequately protected from incidental damage during works.

Given these established controls and protocols it is judged that the residual risk is 'unlikely' to occur but could cause 'moderate harm' - resulting in an overall risk rating of 'Moderate'.

17.2.8 Lack of levee material

Prior to detailed design the North Central CMA will engage local landholders to determine availability of close sources of soil required for construction. Construction costs in this Business Case include upper limit costs for transporting soil from a distance. With this mitigation control in place the residual risk is considered to be 'Moderate'.

17.3 Project management

There are risks arising from the project management aspect of the implementation phase outlined below. These risks could be from a number of sources, which will trigger a range of different risk mitigation strategies and controls.

The North Central CMA has a proven track record in successfully delivering a vast range of environmental projects which have varied in complexity, monetary value and in spatial extent. It has a robust project management framework, with delivery arrangements formalised via a range of mechanisms including operating agreements, service level agreements and landholder incentive/tender management agreements and the application of comprehensive MERI frameworks. Project management processes for this Project will include clear and detailed project plans, clearly documented project progress against milestones.

17.3.1 Approval delays

The *Regulatory Approvals Strategy* (DEPI 2014c) provides a detailed review of the approvals required for implementation of the Project. The Project plan will outline proposed timelines with appropriate contingencies to account for potential delays. DEPI will also provide statewide oversight on the approvals process on behalf of Victoria.

17.3.2 Loss of staff capacity

Effective and efficient project management requires skilled and experienced staff, particularly for Projects that are multidisciplinary involving ecological, hydrological and engineering relationships. The time lag between submission of business cases for assessment to the Australian Government and notification of approval poses a risk that key staff involved in planning and development of the Project will no longer be available for the implementation phase. This risk will be mitigated through collaborative statewide and Basin wide approaches to skill resourcing and development. The residual risk is considered to be 'moderate' as there is limited control over the availability of funding to retain staff during this key period.

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Appendix 1: Species lists

Table 1. Flora species found in Guttrum and Benwell Forests (SKM 2007; Bennetts 2014; Biosis 2014a, 2014b; DSE 2010)

Species Name	Common Name	EPBC	VIC	FFG
Acacia dealbata subsp. dealbata	Silver Wattle			
Alternanthera denticulata s.s.	Lesser Joyweed			
Alternanthera nodiflora	Common Joyweed			
Amyema miquelii	Box Mistletoe			
Bolboschoenus medianus	Marsh Club-sedge			
Brachyscome basaltica var. gracilis	Woodland Swamp-daisy			P
Callitriche sonderi	Matted Water-starwort			
Calotis scapigera	Tufted Burr-daisy			P
Cardamine moirensis	Riverina Bitter-cress		r	
Carex inversa	Knob Sedge			
Carex tereticaulis	Poong'ort			
Centella cordifolia	Centella			
Centipeda cunninghamii	Common Sneezeweed			P
Centipeda minima subsp. minima s.s.	Spreading Sneezeweed			P
Chenopodium curvispicatum	Cottony Saltbush			
Cotula australis	Common Cotula			P
Crassula colorata	Dense Crassula			
Cyperus exaltatus	Tall Flat-sedge			
Dysphania pumilio	Clammy Goosefoot			
Eclipta platyglossa	Yellow Twin-heads			P
Einadia nutans	Nodding Saltbush			
Elatine gratioloides	Waterwort			
Eleocharis acuta	Common Spike-sedge			
Enchylaena tomentosa var. tomentosa	Ruby Saltbush			
Epilobium billardierianum subsp. billardierianum	Smooth Willow-herb			
Epilobium billardierianum subsp. cinereum	Grey Willow-herb			
Eucalyptus camaldulensis	River Red-gum			
Euchiton involucratus s.l.	Common Cudweed			P
Euchiton involucratus s.s.	Star Cudweed			
Euchiton sphaericus	Annual Cudweed			P
Euphorbia drummondii	Flat Spurge			
Exocarpos strictus	Pale-fruit Ballart			

Species Name	Common Name	EPBC	VIC	FFG
Geranium sp. 5	Naked Crane's-bill			
Glinus lotoides	Hairy Carpet-weed			
Glinus oppositifolius	Slender Carpet-weed			
Helichrysum luteoalbum	Jersey Cudweed			P
Juncus amabilis	Hollow Rush			
Juncus aridicola	Tussock Rush			
Juncus flavidus	Gold Rush			
Juncus ingens	Giant Rush			
Juncus subsecundus	Finger Rush			
Juncus usitatus	Billabong Rush			
Lachnagrostis filiformis s.s.	Common Blown-grass			
Lobelia concolor	Poison Pratia			
Lobelia pratioides	Poison Lobelia			
Ludwigia peploides subsp. montevidensis	Clove-strip			
Lycopus australis	Australian Gipsywort			
Lythrum hyssopifolia	Small Loosestrife			
Marsilea costulifera	Narrow-leaf Nardoo			P
Marsilea drummondii	Common Nardoo			P
Marsilea hirsuta	Short-fruit Nardoo			P
Mentha australis	River Mint			
Myosurus australis	Mousetail			
Myriophyllum crispatum	Upright Water-milfoil			
Nymphoides crenata	Wavy Marshwort		v	L, P
Oxalis perennans	Grassland Wood-sorrel			
Paspalidium jubiflorum	Warrego Summer-grass			
Persicaria prostrata	Creeping Knotweed			
Phragmites australis	Common Reed			
Poa labillardierei var. labillardierei	Common Tussock-grass			
Polygonum plebeium	Small Knotweed			
Ranunculus inundatus	River Buttercup			
Ranunculus lappaceus	Australian Buttercup			
Ranunculus sessiliflorus var. sessiliflorus	Annual Buttercup			
Rhagodia spinescens	Hedge Saltbush			
Rorippa laciniata	Jagged Bitter-cress			
Rumex bidens	Mud Dock			

Species Name	Common Name	EPBC	VIC	FFG
Rumex brownii	Slender Dock			
Rytidosperma setaceum	Bristly Wallaby Grass			
Senecio campylocarpus	Floodplain Fireweed		r	P
Senecio cunninghamii var. cunninghamii	Branching Groundsel		r	P
Senecio quadridentatus	Cotton Fireweed			P
Senecio runcinifolius	Tall Fireweed			P
Stellaria angustifolia	Swamp Starwort			
Stellaria caespitosa	Matted Starwort			
Triglochin procera s.s.	Common Water-ribbons			
Vittadinia cuneata var. cuneata	Fuzzy New Holland Daisy			P
Wahlenbergia communis s.s.	Tufted Bluebell			
Wahlenbergia fluminalis	River Bluebell			
Wahlenbergia gracilenta s. l	Annual Bluebell			
Wahlenbergia gracilis	Sprawling Bluebell			
Xerochrysum bracteatum	Golden Everlasting			P

Table 2. Fauna species found in Guttrum and Benwell Forests (SKM 2007; Bennetts 2014; Biosis 2014a, 2014b; DSE 2010)

Species Name	Common Name	EPBC	VIC	FFG
Acanthiza nana	Yellow Thornbill			
Acanthiza reguloides	Buff-rumped Thornbill			
Acrocephalus stentoreus	Clamorous Reed Warbler			
Alcedo azurea	Azure Kingfisher		nt	
Anas gracilis	Grey Teal			
Anas superciliosa	Pacific Black Duck			
Anhinga novaehollandiae	Darter			
Antechinus flavipes	Yellow-footed Antechinus			
Apus pacificus	Fork-tailed Swift			
Aquila audax	Wedge-tailed Eagle			
Ardea alba	Great Egret	V		L
Ardea intermedia	Intermediate Egret		en	L
Ardea modesta	Eastern Great Egret		vu	L
Aredea pacifica	White-necked Heron			
Artamus cyanopterus	Dusky Woodswallow			
Botaurus poiciloptilus	Australasian Bittern	EN	en	L
Bubulcus ibis	Cattle Egret			
Cacatua galerita	Sulphur-crested Cockatoo			
Cacatua sanguinea	Little Corella			
Cacomantis flabelliformis	Fan-tailed Cuckoo			
Callocephalon fimbriatum	Gang-gang Cockatoo			
Chelodina longicollis	Common Long-necked Tortoise			
Chenonetta jubata	Australian Wood Duck			
Cincloramphus mathewsi	Rufous Songlark			
Circus approximans	Swamp Harrier			
Climacteris picumnus victoriae	Brown Treecreeper (south-eastern ssp.)		nt	
Colluricincla harmonica	Grey Shrike-thrush			
Coracina novaehollandiae	Black-faced Cuckoo-shrike			
Corcorax melanorhamphos	White-winged Chough			
Cormobates leucophaea	White-throated Treecreeper			
Corvus coronoides	Australian Raven			
Cracticus tibicen	Australian Magpie			
Crinia parinsignifera	Plains Froglet			
Crinia signifera	Common Froglet			
Cuculus pallidus	Pallid Cuckoo			
Dacelo novaeguineae	Laughing Kookaburra			
Daphoenositta chrysoptera	Varied Sittella			

Species Name	Common Name	EPBC	VIC	FFG
Dicaeum hirundinaceum	Mistletoebird			
Egernia striolata	Tree Skink			
Egretta garzetta	Little Egret		en	L
Egretta novaehollandiae	White-faced Heron			
Entomyzon cyanotis	Blue-faced honeyeater			
Eolophus roseicapillus	Galah			
Eopsaltria australis	Eastern Yellow Robin			
Falco peregrinus macropus	Peregrine Falcon			
Falcunculus frontatus	Crested Shrike-tit			
Gallinago hardwickii	Latham's Snipe		nt	N
Geopelia striata	Peaceful Dove			
Gerygone fusca	Western Gerygone			
Grallina cyanoleuca	Magpie-lark			
Grantiella picta	Painted Honeyeater			
Haliaeetus leucogaster	White-bellied Sea Eagle		vu	L
Haliastur sphenurus	Whistling Kite			
Hirundo neoxena	Welcome Swallow			
Lampropholis guichenoti	Garden Skink			
Lichenostomus penicillatus	White-plumed Honeyeater		vu	L
Limnodynastes dumerilii dumerilii	Pobblebonk Frog			
Limnodynastes tasmaniensis NCR	Spotted Marsh Frog NCR			
Litoria raniformis	Growling Grass Frog	VU	en	L
Macropus giganteus	Eastern Grey Kangaroo			
Malurus cyaneus	Superb Fairy-wren			
Manorina melanocephala	Noisy Miner			
Melithreptus brevirostris	Brown-headed Honeyeater			
Melithreptus gularis	Black-chinned Honeyeater		nt	
Melithreptus lunatus	White-naped Honeyeater			
Merops ornatus	Rainbow Bee-eater			
Microcarbo melanoleucos	Little Pied Cormorant			
Microeca fascinans	Jacky Winter			
Myiagra inquieta	Restless Flycatcher			
Neochmia temporalis	Red-browed Finch			
Ninox novaeseelandiae	Southern Boobook			
Notechis scutatus	Tiger Snake			
Nycticorax caledonicus	Nankeen Night Heron		nt	
Oriolus sagittatus	Olive-backed Oriole			
Pachycephala pectoralis	Golden Whistler			

Species Name	Common Name	EPBC	VIC	FFG
Pachycephala rufiventris	Rufous Whistler			
Pardalotus striatus	Striated Pardalote			
Passer domesticus	House Sparrow		en	L
Pelecanus conspicillatus	Australian Pelican			
Petaurus breviceps	Sugar Glider			
Petrochelidon nigricans	Tree Martin			
Phalacrocorax carbo	Great Cormorant			
Phalacrocorax varius	Pied Cormorant		nt	
Philemon citreogularis	Little Friarbird			
Platalea regia	Royal Spoonbill		nt	
Platycercus elegans	Crimson Rosella			
Platycerus elegans flaveolus	Yellow Rosella			
Platycercus eximius	Eastern Rosella			
Plegadis falcinellus	Glossy Ibis		nt	
Podargus strigoides	Tawny Frogmouth			
Podiceps cristatus	Great Crested Grebe			
Pomatostomus temporalis	Grey-crowned Babbler		en	L
Psephotus haematonotus	Red-rumped Parrot			
Rhipidura albiscapa	Grey Fantail			
Rhipidura leucophrys	Willie Wagtail			
Sericornis frontalis	White-browed Scrubwren			
Smicrornis brevirostris	Weebill			
Stagonopleura guttata	Diamond Firetail		nt	L
Strepera graculina	Pied Currawong			
Tadorna tadornoides	Australian Shelduck			
Threskiornis molucca	Australian White Ibis			
Todiramphus sanctus	Sacred Kingfisher			
Trichosurus vulpecula	Common Brushtail Possum			
Wallabia bicolor	Black Wallaby			
Zosterops lateralis	Silvereye			

Table 3: Threatened species likely to occur in the project area

Species Name	Common Name	EPBC	VIC	FFG
Burhinus grallarius	Bush-stone Curlew			L
Chelodina expansa	Broad-shelled Turtle		en	L
Cygnus atratus	Black Swan			
Falco subniger	Black Falcon		vu	
Hirundapus caudactus	White-throated Needletail		vu	
Melanodryas cucullata	Hooded Robin		nt	L
Ninox connivens	Barking Owl			L
Pogona barbata	Bearded Dragon		vu	
Varanus varius	Lace Goanna		en	

Appendix 2: Water Regime Class descriptions

The following descriptions of Water Regime Classes are excerpted from Ecological Associates (2013).

Permanent Wetland

A small billabong is located in Guttrum Forest to the east of Reed Bed Swamp and is the only permanent wetland in the forests (**Error! Reference source not found.**). The wetland has a relatively high inflow threshold, but is more than 5 m deep and would rarely, if ever, dry out under natural conditions.

Inflows to the billabong commence at flows exceeding 30,000 ML/d which, under natural conditions, was exceeded in approximately 50% of years for a duration of 1 to 3 months (interquartile range). Between inflow events water would be gradually lost to evaporation and seepage and the water level would fall.

The steep sides and large, infrequent fluctuations in water level represent unsuitable habitat for emergent macrophytes, and the edges of the wetland are bare. A relatively small surface area is exposed and reflooded during the flooding cycle and there is little scope to the mineralisation the organic matter which accumulates on the wetland bed. The food web mainly depends on external organic matter inputs from leaf fall and flood water. Nutrient and carbon generation within the wetland are provided by algae, semi-emergent aquatic macrophytes (such as *Myriophyllum* sp.) and biofilms on the abundant large woody debris at the fringes of the wetland.

The deep billabong in Guttrum Forest represens the only permanent wetland habitat in the forests

The billabong would support a relatively species-poor climax community of aquatic invertebrates comprising large zooplankton (particularly Cladocera and Ostracoda), shrimp (*Paratya* sp. and *Macrobrachium* sp.) and large insect larvae such as mayfly and dragonfly. These fauna, together with vegetation and biofilms would support small fish species such as gudgeons, common galaxias and crimson-spotted rainbow fish. Large predatory native fish, such as Murray cod and golden perch, and tortoises may be trapped in the billabong after floods, but the wetland is small and would not support significant populations of these species.

The steep sides of the billabong provide little habitat for wading birds, however waterfowl would feed and rest in and near the billabong.

The billabong is small in extent and makes a small contribution to the habitat diversity of the forest compared to other wetlands. However, permanent wetlands set within forest areas are important to a number of floodplain fauna species that feed or roost near waterbodies and watercourses, such as myotis bat.

The key attributes of the permanent wetland to promote are:

- reliable flooding to 2 to 5 m
- beds of submerged aquatic macrophytes
- resident populations of small native fish
- feeding and resting habitat for dabbling ducks and diving waterbirds
- recolonisation and dispersal of aquatic fauna during flood events

These attributes will be promoted by a flooding regime of:

- filling events in 50% of years
- overtopping the wetland for 2 weeks to 2 months in each event
- water level is never less than 2 m deep

Semi-permanent Wetlands

Semi-permanent wetland habitat is provided in Reed Bed, Little Reed Bed, Guttrum Swamp, Benwell Swamp and Southwest Benwell Swamp. Water is normally present in these wetlands, but they are shallow and would dry out from time to time.

The wetlands share a similar hydrology. Inflows commence between 17,000 to 23,000 ML/d, and under natural conditions occur approximately 9 out of 10 years with events lasting 3 to 6 months (interquartile range at 21,000 ML/d). The wetlands retain water on the flood recession to a depth of 0.5 to 0.7 m and would usually remain flooded during summer. The wetlands would often dry out in autumn but in wet years may remain flooded until the following winter. Reed Bed Swamp retains water to a greater depth of 0.85 m and is more likely to remain flooded throughout the year.

The wetlands provide habitat for marshland, open water and reed bed plant communities. Red gum are excluded by prolonged flooding.

Reed bed vegetation grows in areas flooded to approximately 1 m in spring with water typically receding to less than 0.5 m over summer. Spring flooding promotes *Bolboschoenus medianus, Pseudoraphis spinescens, Schoenoplectus validus* and *Triglochin procerum*, and these species would be dominant in the shallower wetlands dry out early. Flooding would persist longer into summer and autumn in the deeper wetlands, particularly Reed Swamp, and these areas would be dominated by the summer-growing macrophytes *Typha domingensis, Phragmites australis, Juncus ingens* and *Eleocharis sphacelata* (**Error! Reference source not found.**). The wetland fringes would support a herbland of low-growing emergent species, such as *Eleocharis acuta* and amphibious plants such as *Alternanthera denticulata, Ludwigia peploides* and *Myriophyllum* spp.

The wetlands represent a highly productive and diverse environment important to a range of fauna species. Seasonal inundation and exposure mineralises organic matter and supports microbial and planktonic productivity soon after flooding commences. During spring larger aquatic invertebrates, frogs and small fish species proliferate, providing food sources for large wading birds and piscivores. Receding flood water in summer provides habitat for migratory wading birds that pick over invertebrates in drying mud.

The wetlands are an important component of breeding habitat for waterbirds. As well as providing a food source, the vegetation provides shelter, nesting habitat and nesting materials.

Dense macrophyte beds are an important habitat component for cryptic waterbirds. Historically, Reed Swamp supported Australasian bittern, purple swamp hen and black-tailed native hen. Dense reed beds provide nesting habitat for swamp harrier. Persistently flooded reed beds are also important to growling grass frog.

Marshy areas with semi-emergent vegetation are important to grebes and dabbling ducks. Great crested grebe and Australasian grebe have been present in Guttrum and Benwell Forests and have often bred at Reed Bed Swamp.

Flooding of the wetlands, together with the fringing red gum forest provides habitat for colonial nesting waterbird colonies. Round Reed Swamp is a regionally significant colonial nesting waterbird breeding site (Disher, 2000). The wetland provides foraging areas, habitat to build platform nests and a source of nesting materials. The ridge that surrounds the wetland may be important to its value to breeding waterbirds. The ridge provides slightly drier ground for river red gum to grow in close proximity to deeper water, which is where many waterbirds build nests.

The key attributes of the permanent wetland to promote are:

- beds of summer-growing emergent macrophytes, particularly *Typha domingensis* and *Juncus ingens*
- beds of spring growing emergent macrophytes, such as *Bolboschoenus medianus* and *Schoenoplectus validus*
- marshlands of semi-emergent macrophytes including *Pseudoraphis spinescens*, *Myriophyllum* sp. and *Potamogeton* sp.
- flooded reedy habitat for growling grass frog, crake, bittern, swamphen, moorhen, swamp harrier and other species dependent on reeds
- frequent breeding events by cryptic and platform building waterbirds
- productive foraging habitat for waterbirds including dabbling species, wading birds and piscivores
- exclusion of red gum
- resident populations of small fish

These attributes will be promoted by a flooding regime of:

- flooding to fill the wetlands in 70% of years, lasting 3 to 6 months
- flooding to fill the wetlands in a further 20% of years, lasting 1 month
- only 5% of events separated by more than 18 months
- flooding commencing in June, July or August

Red Gum with Flood-dependent Understorey

Red gum with flood-dependent understorey occurs in Guttrum and Benwell in areas which have a low flooding threshold but do not retain deep water when flood water recedes.

At Benwell Forest forest flooding commences at flows exceeding 18,000 ML/d and at Guttrum at flows exceeding 20,000 ML/d. Flooding of the Red Gum EDU is largely complete at flows of 26,000 ML/d. Under natural conditions the forest is flooded in approximately 8 years out of 10 for 2 to 5 months (interquartile range at 23,000 ML/d) with flooding typically occurring between June and December.

The forest understorey supports a grassy understorey of perennial species that require seasonal flooding. The dominant species are *Paspalidium jubiflorum*, *Carex tereticaulis* and *Juncus usitatus*, combined with *Phragmites australis*, *Typha domingensis* and *Juncus ingens* in local depressions. A seasonal community of submerged aquatic macrophytes develops in winter and spring, but dies off in summer as the forest dries out (**Error! Reference source not found.**). Important species include *Eleocharis acuta* and *Althernanthera denticulata*.

The recession of flood water provides a highly productive environment for terrestrial fauna over summer and autumn. The understorey provides seeds, fruit and forage for granivores such as finches, cockatoos, galah, lorikeet and budgerigar, the frugivorous emu and herbivorous swamp wallaby. The trees directly support nectivorous and omnivorous birds such as honeyeaters and wattlebird. Both overstorey and understorey support insect production on which a wide range of birds and reptiles depend.

Red Gum with flood-dependent understorey in autumn 2013, with drying aquatic plants in the understorey

When flooded, the forest provides habitat for invertebrates, fish and other aquatic fauna. Flooding triggers the rapid decay and release of minerals and carbon from organic debris on the forest floor, supporting an aquatic food web of microbes, invertebrates and small fish. Large fish species in the river channel migrate to the flooded forest to make use of these resources and the flooded forest provides important nursery habitat for juvenile fish.

Forest flooding, particularly near the wetlands, is important to waterbird breeding. The Reed Bed is a regionally significant colonial nesting waterbird breeding, of similar importance to the Little Gunbower wetland complex in Gunbower Forest. Generally flooding must last long enough for a productive food web to develop and for birds to respond physiologically. Birds that feed on insects and other food sources that appear early during floods, such as ibis, tend to breed early in the season. Birds that feed on fish (such as darter, little black cormorant and intermediate egret), that become increasingly abundant towards summer, breed later. In general, flooding must persist from 3 months, for small breeding events, to 10 months, for large breeding events that include a wider variety of bird species. Water draining from the forest is rich in dissolved organic carbon and conveys woody debris, which are important for the riverine food web.

The key attributes of red gum with flood-dependent understorey to promote are:

- high levels of tree and understorey productivity
- an understorey dominated by sedges, rushes and other flood-depdendent species
- frequent waterbird breeding events, including colonial nesting species near wetlands
- seasonal habitat for small floodplain and riparian fish species and for large riverine fish species and their juveniles
- export of organic carbon to the River Murray

These attributes will be promoted by a flooding regime of:

- flooding the entire area in 50% of years, for 2 to 5 months
- flooding the entire area in a further 20% of years, for 1 month

- only 5% of events separated by more than 3 years
- flooding commencing in June, July or August

Red Gum Forest with Flood-tolerant Understorey

Red Gum with flood-tolerant understorey occurs on the elevated floodplain floor along the natural levee formed on the river bank in Guttrum and Benwell Forests.

Inundation commences at 28,000 ML/d as water encroaches from the central floodplain floor. Flooding is largely complete at 34,000 ML/d as overbank flow becomes widespread. However areas of the floodplain levee remain unflooded at these high flows. Under natural conditions flooding occurs in approximately 5 years out of 10 for 1 to 3 months (interquartile range at 31,000 ML/d).

The forest understorey comprises a grassy understorey of *Eleocharis pusilla, Amphibromus nervosus,* and *Bolboschoenus medianus*. Drier areas support a more terrestrial understorey of *Enchylaena tomentosa, Einadia nutans* and *Atriplex semibaccata. Exocarpus strictus* is found throughout this water regime class (**Error! Reference source not found.**).

Despite a similar flooding regime to dryer areas at the landward edges of the forest, the river levee supports a high proportion of wetland plants, particularly *Bolboschoenus medianus*, and vegetation may access additional soil water in the capillary zone above the water table along the river bank.

Pale fruit ballart (*Exocarpus strictus*) is an important plant for many bird species inlcuding painted button-quail, white-browed scrubwren, brown thornbill, Gilbert's whistler and white-browed babbler.

Red gum with flood-tolerant understorey showing grasses and cherry ballart

Key attributes of the red gum with flood-tolerant understorey to promote are:

- high levels of tree and understorey productivity
- an understorey dominated by grasses and drough-tolerant sedges and rushes

These attributes will be promoted by a flooding regime of:

- flooding the entire area in 40% of years, for 1 to 3 months
- flooding the entire area in a further 10% of years, for 2 weeks

- flooding commencing in June, July or August

Appendix 3: Risk assessment methodology

Introduction

A comprehensive environmental, social and economic risk assessment in line with AS/NZS ISO 31000:2009 has been completed by the North Central CMA for the Guttrum and Benwell Environmental Works Project. The process for completing the risk assessment involved the following:

- A risk register (Appendix 4) 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 with a score against:
  - The likelihood of those events occurring
  - The severity of the outcome if the event occurred
  - A consequential risk rating
  - The available mitigation strategies and controls to offset these risks
  - The residual risk once those controls were imposed.
- The risk register was subject to critique, challenge and validation by a panel of stakeholders with a wide range of expertise (NCCMA, GMW, DEPI, Parks Victoria, MDBA, Campaspe Shire and the Gannawarra Shire) who:
  - Identified the key risks that merited priority attention. These were defined as any risks with a score of 8 or above, with a focus on the categories 'High' or 'Very High'
  - Confirmed appropriate mitigation controls
  - Agreed to the residual risk after mitigation options were identified.

Risk assessment methodology and approach

The risk assessment assesses the potential risks against the variables of 'Likelihood' and 'Consequence'. That then allocates each risk an overall rating from A - D in line with the methodology in ISO 31000:2009, Risk management. Table 1 presents the risk management matrix used and Table 2 and 3 present the likelihood and consequence descriptions respectively.

Table 0-1: ISO Risk management matrix

	Consequence				
Likelihood	Negligible	Minor	Moderate	Major	Extreme
Almost certain	D	C	B	A	A
Likely	D	C	B	A	A
Possible	D	C	C	B	[illegible]
Unlikely	D	D	C	B	[illegible]
Rare	D	D	D	C	B

The five different ratings for the likelihood of an event occurring are presented in Table 2.

Table 0-2: Risk Likelihood Description

Rating		Description	% Probability
Rare	1	Event may occur only in exceptional circumstances	0-5
Unlikely	2	The event could occur at some time	5-20
Possible	3	The event might occur	20-50
Likely	4	The event will probably occur in most circumstances	50-80
Almost certain	5	The event is expected to occur in most circumstances	80-100

ble 0-3: Consequence Description

Rating	Environment *Impact on the surrounding environment, including habitats and species, as well as the broader landscape*	Business Costs *Cost to the state*	People *Workers, local communities and other stakeholders* Safety and Well-being	People and Culture	Political/ Reputational *How media, public and stakeholder perception of State is influenced*	Legal *Legal consequence*	Service Delivery *Effect on the business*
egligible Harm	No material effect on the environment, contained locally within a single site/ area. Environment affected for days	Cost impact of up to 2.5% of allocated operational budgets (including capital budget); OR a cost impact of up to $2.5m	On-site first aid treatment only	Staff disgruntlement	Minimal adverse local attention (1 day only)	Non-compliance with legislation, identified internally and resulting in internal acknowledgement and process review.	Insignificant impact to the Department's capability in providing its services - no inconvenience to customers/ stakeholders
nor Harm	Limited effect on the environment, restricted to a single township or locality. Environment affected for weeks.	Cost impact between 5%-10% of allocated operational budgets (including capital budget); OR a cost impact of up to $5m	Minor injuries/illness requiring medical attention	Complaints, passively upset, and uncooperative	Adverse localised public attention on a single issue over a short period. (up to 1 week)	Non-compliance with legislation or breach of duty of care, identified externally and either (1) resolved without prosecution of or civil action, or (2) resulting in prosecution or civil action involving low level of resourcing required to defend, exposure to low level remedies or damages, and low level risk of negative precedent	Minimal short term temporary impa to the Department's capability in providing its services - customers/ stakeholders slightly inconvenienced
oderate m	Moderate effect on the environment, impacting on a municipality or multiple localities. Environment affected for months.	Cost impact >10% of allocated operational budgets (including capital budget); OR a cost impact of up to $10m	Significant injury/illness requiring in-patient hospitalisation	Low morale, disengagement, increased absenteeism and workplace conflict	Adverse localised negative public attention on a single issue over a sustained period (up to 2 months)	Non-compliance with legislation or breach of duty of care resulting in prosecution of, or civil action, with one of high level of resourcing required to defend; exposure to high level remedies or damages or high level risk of negative precedent.	Significant impact to the Department's capability in providing its services - customers/ stakeholder inconvenienced
jor Harm	Major effect on the environment, impacting on a region or multiple municipalities. Environment affected for 1-3 years.	Cost impact between $10m-$50m	Extensive and/or permanent injury/ illness	Major morale issues, high absenteeism and resignations of key staff	Serious adverse public attention on more than one issue over a prolonged period (up to 2 years)	Non-compliance with legislation or breach of duty of care resulting in prosecution of or civil action (with all of high level of resourcing required to defend, exposure to high level remedies or damages, and high level risk of negative precedent) or public enquiry	Continuing difficulties in the Department's capability in servicing customers/stakeholders over a protracted period
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	Likelihood	Consequence	Rating		Likelihood	Consequence	Rating		
·egetation in ·l, causing a loss ·dance of the	Almost certain	Minor Harm	C	Detailed designs and site surveys to minimise impacts. Works supervision. Vegetation management plans. Follow relevant legislation. Establish monitoring program	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor	Gun Mar Pha: 201: Upp Asse Gutt Enh: Pha: 201:
·understorey may be ·il compaction),	Almost certain	Minor Harm	C	Detailed designs and site surveys to minimise impacts. Works supervision. Vegetation management plans. Follow relevant legislation. Establish monitoring program	Unlikely	Minor Harm	D	Project Manager and Construction Contractor	Upp Asse
proper hygiene ·nay enter the ·new or condition of the ·una.	Possible	Moderate Harm	C	Site Environment Management Plan (hygiene protocols and enforcement, contractor management)	Possible	Minor Harm	C	Project Manager and Construction Contractor	Upp Asse
·dopted during causing ·r water	Possible	Minor Harm	C	Site Environment Management Plan . Works supervision (site rehabilitation)	Unlikely	Minor Harm	D	Project Manager and Construction Contractor	Upp Asse
·ted with native fauna, ·luce in diversity	Possible	Moderate Harm	C	Construction Management Plan developed	Unlikely	Minor Harm	D	Project Manager and Construction Contractor	Upp Asse
can be ·red causing the ·reduced.	Unlikely	Minor Harm	D	Construction Management Plan developed	Unlikely	Minor Harm	D	Project Manager and Construction Contractor	Upp Asse
of biodiversity (and potentially	Possible	Extreme Harm	A	Fire management plan developed. Site Environment Management Plan . Site safety plans.	Unlikely	Major Harm	B	Project Manager and Construction Contractor	Upp Asse
·n, cultural, assets, commercial and recreational)									
·on hours, the ·ls of noise and ·ll be affected	Unlikely	Minor Harm	D	Site Environment Management Plan and Construction Management Plan, Site safety plans developed.	Unlikely	Minor Harm	D	Project Manager and Construction Contractor	Upp Asse
present in the ·ed or	Possible	Major Harm	B	Cultural Heritage Management Plan developed.	Unlikely	Moderate Harm	C	Project Manager and Construction	SDL

rn 80 ski race, it ence to race : don't attend	Unlikely	Minor Harm	D	Traffic Management Plan developed	Rare	Minor Harm	D	Project Manager and Construction Contractor	Gun Soci
riods, excessive pollution and ommunity.	Possible	Minor Harm	C	Construction Management Plan developed	Unlikely	Minor Harm	D	Project Manager and Construction Contractor	Upp Asse
d by people, ng the the local	Likely	Negligible Harm	D	Ongoing stakeholder engagement. Site rehabilitation	Unlikely	Minor Harm	D	NCCMA, Project Manager, Construction Contractor	SDL (201 Con
	Possible	Moderate Harm	C	Design to minimise vandalism. Inspection and maintenance	Unlikely	Minor Harm	D	NCCMA, Asset owner	Con
s of the forest these pursuits sing community.	Unlikely	Minor Harm	D	Implement stakeholder management strategy - ongoing engagement with community through multiple avenues. Adequate warning before events	Unlikely	Negligible Harm	D	NCCMA	SDL (201
al roads eriods, there pair costs and	Possible	Minor Harm	C	Traffic Management Plan. Ongoing engagement with land managers (DEPI, Parks Victoria) and Local Councils	Unlikely	Minor Harm	D	Project Manager and Construction Contractor	Gun Soci
tified prior to using repair	Unlikely	Minor Harm	D	Detailed designs and site surveys to identify essential services locations. Works supervision.	Unlikely	Negligible Harm	D	Project Manager and Construction Contractor	Gun Soci
not followed es may be causing injury	Unlikely	Major Harm	B	Traffic Management Plan developed	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor	Gun Soci
nstruction community ensation.	Unlikely	Extreme Harm	B	Construction Management Plan developed	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor	Gun Soci
municated roject, causing	Unlikely	Minor Harm	D	Implement stakeholder management strategy - ongoing engagement with community through multiple avenues.	Unlikely	Minor Harm	D	NCCMA	SDL (201
and supportive re the land	Possible	Major Harm	B	In-principle agreements with landowners to purchase land for channels if project is funded. Alternate alignments if primary alignments not available. Land valuations conducted so acquisitions to be properly funded. Ongoing engagement with landholders and involvement in channel supply design	Unlikely	Moderate Harm	C	NCCMA	Con Lanc Stak In-pi corr
ot include tors may result nding	Possible	Moderate Harm	C	Detailed designs to refine costs and contingencies. Peer review of cost estimates. Adequate contingency against level of risk	Unlikely	Minor Harm	D	NCCMA	Gun Soci
pted then the	Unlikely	Moderate	C	Peer review of designs.	Unlikely	Moderate	C	Project Manager and	Con

ather could cause re-mobilisation	Possible	Major Harm	B	Proper advance notice/lead times for warnings, known travel time for water movement. Liaison with VEHW/CEWH. Contrctual arrangements with contractors. Contingency planning. Insurance (contractor, equipment, liability)	Possible	Minor Harm	C	Project Manager and Construction Contractor	Con
npromise the ructure this comes cannot	Possible	Major Harm	B	Early enagagement of contractors. Peer review of designs	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor	TLM (201
	Unlikely	Major Harm	B	Insurance (contractor, equipment, liability). Fire management plan developed. Site EMP. Site safety plans.	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor	TLM (201
iction	Unlikely	Moderate Harm	C	Ongoing engagement with irrigators and GMW. Work will be conducted outside irrigation season	Rare	Moderate Harm	D	NCCMA, Project Manager	SDL 201
dequate levee ect site	Possible	Major Harm	B	Upper limit costs for levee construction are in the budget and prior to detail design, engagement with local landholders will determine availability of closely sources material.	Unlikely	Moderate Harm	C	NCCMA, Project Manager	SDL Pers 201
	Unlikely	Minor Harm	D	Construction Management and site safety plans developed	Rare	Negligible Harm	D	NCCMA, Project Manager	Hipv
	Possible	Major Harm	B	Identify timeframes for approval processes (critical path) and have contingency planning	Unlikely	Moderate Harm	C	NCCMA, Project Manager	SDL
being	Possible	Moderate Harm	C	Connection to CSD for off-farm rainwater drainage	Unlikely	Minor Harm	D	NCCMA, Project Manager	Pers 201
	Possible	Moderate Harm	C	Thorough contractual arrangements (ie. milestones, allowances, risk responsibility, etc). Contractor supervision	Rare	Moderate Harm	D	NCCMA	Hipv
tion and ing and works project	Possible	Moderate Harm	C	Thorough project planning with time contingency factored in to cater for unforeseen delays	Unlikely	Moderate Harm	C	NCCMA	Seas Fore
he business, ponse) project, loss of	Possible	Major Harm	B	Clear and detailed project plan including clearly articulated milestones. Clear documentation of project information and progress. Targeted recruitment process (if required) with clear description of role defintion.	Possible	Moderate Harm	C	NCCMA	SDL
the natural atic flora may communities	Possible	Moderate Harm	C	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA	App wat Ben SDL

ɘd plant				evaluation program.					SDL
tive parts of ; (e.g. Alligator Dense e weeds may lant diversity to	Possible	Moderate Harm	C	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Likely	Minor Harm	C	NCCMA	Gun Ecol (Eco SDL
onmental ıs weeds (e.g. Pattersons ey species to be ıd degraded	Unlikely	Minor Harm	D	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Possible	Minor Harm	C	NCCMA	Gun Ecol (Eco SDL
ter or damp soil Gum ur in the g wetland plant at value for fish	Unlikely	Major Harm	B	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA	Gun Ecol (Eco Upp (Eco SDL
deep) in some ring, Giant Rush unners, causing l, loss of open waterbirds to	Possible	Major Harm	B	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Possible	Moderate Harm	C	NCCMA	Gun Ecol (Eco SDL
t is drained insufficient to or flood- River Red Gum onse (low	Possible	Minor Harm	C	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA	Gun Ecol (Eco SDL
wetland ne nsufficient to tive impacts, espond and/or for flora and	Unlikely	Minor Harm	D	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA	Gun Ecol (Eco SDL
hydrological tion, the Black ndated for too death and	Unlikely	Moderate Harm	C	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA	Gun Ecol (Eco SDL

opriate duration heir nests l local diversity	Unlikely	Moderate Harm	C	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA	Gun Ecol (Eco SDL
frequently insufficient to ig poor and abundance.	Unlikely	Moderate Harm	C	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA	Gun Ecol (Eco SDL
a long dry n compromises breeding	Possible	Minor Harm	C	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA	Gun Ecol (Eco SDL
e high organic dissolved s) may result,	Likely	Moderate Harm	B	Plan flooding with regard to quality of incoming water. Monitor antecedent floodplain conditions (organic matter loads). Risk management plan in place. Manage through-flow to help manage risk. Monitor risk factors (DO, temp) and manage flooding to manage risk. Disposing of blackwater - manage outflow rates to ensure dilution. Flood frequency - prevent high organic load build-up	Unlikely	Minor	D	NCCMA	Gun Ecol (Eco
ved oxygen or er water layer, decline.	Possible	Moderate Harm	C	Plan flooding with regard to quality of incoming water. Monitor antecedent floodplain conditions (organic matter loads). take into account seasonal conditions (eg. blacwater, algae). Risk management plan in palce. Manage through-flow to help manage risk. Monitor risk factors (DO, temp) and manage flooding to manage risk. Disposing of blackwater - manage outflow rates to ensure dilution. Flood frequency - prevent high organic load build-up	Unlikely	Moderate Harm	C	NCCMA	Gun Ecol (Eco
y									
ers and other ich impedes , causing d events.	Rare	Negligible Harm	D	Develop a Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Rare	Negligible Harm	D	NCCMA	Gun Ecol (Eco
vater discharge t load to the	Rare	Negligible Harm	D	groundwater and salinity monitoring and adaptively manage if required	Rare	Negligible Harm	D	NCCMA	Gun Ecol (Eco
rtable, which er and leads to ation on	Unlikely	Moderate Harm	C	groundwater and salinity monitoring and adaptively manage if required	Unlikely	Minor Harm	D	NCCMA	Gun Ecol (Eco

est becomes a en native fish educed	Likely	Minor Harm	C	Develop and implement a fish exit strategy.	Unlikely	Minor Harm	D	NCCMA	Gun Ecol (Eco Gun Fore (Wa
pest fish ncreases the on aquatic ces the	Almost certain	Major Harm	A	Carp screens on all offtake regulators	Likely	Moderate Harm	B	NCCMA	Gun Ecol (Eco
ne forest causing impacts pulations within	Possible	Moderate Harm	C	Carp screens on all offtake regulators	Possible	Minor Harm	C	NCCMA	
al, assets, commercial and recreational)									
breaches may	Likely	Moderate Harm	B	Peer review of designs. Levees repaired or replaced to have minimum 200mm freebaord. Supervision during repair and/or construction. Ongoing inspection and maintenance. Emergency response procedure	Unlikely	Minor Harm	D	NCCMA, Parks Victoria, DEPI	Leve (URS
in the forest ld damage	Possible	Minor Harm	C	Land manager (DEPI, Parks Victoria) consultation to determine options available to minimise damage to tracks (eg. locked gates)	Unlikely	Minor Harm	D	NCCMA, Parks Victoria, DEPI	Seas Fore
ions frequented ıry to a wetland tion.	Rare	Moderate Harm	D	Public notification. Signage at sites. Insurance (public liability)	Unlikely	Minor Harm	D	NCCMA, Parks Victoria, DEPI	Seas Fore
e forest, access harvesting plots e area for	Likely	Minor Harm	C	Implement stakeholder management strategy - ongoing engagement with community through multiple avenues. Adequate warning before events	Possible	Minor Harm	C	NCCMA, Parks Victoria, DEPI	Gun Man Phas 201: Gutt Enha Phas 201:
and or nber	Likely	Moderate Harm	B	Landowner and licencee consultation. Implementing stakeholder management strategy. Warning before events	Possible	Minor Harm	C	NCCMA, Parks Victoria, DEPI	Gun Man Phas 201: Gutt Enha Phas 201:
	Likely	Moderate Harm	B	Landowner and licencee consultation. Implementing stakeholder management strategy. Warning before events	Possible	Minor Harm	C	NCCMA, Parks Victoria, DEPI	Gun Man Phas 201:

e forest, access causing r recreation.	Possible	Minor Harm	C	Agency consultation (Parks Victoria, DEPI). Warning before events through public notification and signage.	Possible	Minor Harm	C	NCCMA, Parks Victoria, DEPI	Gun Man Pha: 201: Gutt Enh: Pha: 201:
e forest, access eading to a penditure - munities	Likely	Moderate Harm	B	Local Councils have eco-tourism in their Strategic and Economic Development Plans. These projects will enhance opportunities for increased tourism	Possible	Minor Harm	C	NCCMA, Parks Victoria, DEPI	Cam Gan
e forest, there ble increase in	Unlikely	Minor Harm	D	Public engagement / notification (people take more precautions which reduce consequences). Inform Council Public Health Officers	Rare	Negligible Harm	D	NCCMA	SDL
on and/or	Possible	Major Harm	B	Cultural Heritage Management Plan developed.	Unlikely	Major Harm	B	NCCMA, Parks Victoria, DEPI	SDL 201 SDL (ACH
s stakeholders	Possible	Major Harm	B	Cultural Heritage Management Plan developed. Ongoing engagement and involvement with Indigeneous groups	Unlikely	Moderate Harm	C	NCCMA	SDL 201 SDL (ACH
alth of the local re risk causing	Possible	Negligible Harm	D	Implement stakeholder management strategy - ongoing engagement with community through multiple avenues	Possible	Minor Harm	C	NCCMA, Parks Victoria, DEPI	Gun Soci
nnel). Remote on of regulators	Likely	Minor Harm	C	Maintenance and operations built into workplan	Possible	Negligible Harm	D	NCCMA, Asset owner / operator	SDL 201
ould breach the heavy	Unlikely	Moderate Harm	C	Infrastructure designed to not require heavy manual handling or equipment to be used to handle heavy items (eg. tray mounted crane for lifting drop boards/plates)	Rare	Moderate Harm	D	NCCMA, Asset owner / operator	SDL 201
	Unlikely	Extreme Harm	B	Peer review of designs. Adequate geotech investigations. Supervision during construction. Ongoing inspection and maintenance. Emergency response procedure	Rare	Major Harm	C	NCCMA, Asset owner / operator	Leve (URS
el/pump) ody debris or nsufficient in g reduced	Possible	Minor Harm	C	Ongoing inspections and maintenance program. As most infrastrucure is having water delivered through the irrigation system, unlikey to be problematic	Unlikely	Minor Harm	D	NCCMA, Asset owner / operator	Seas Fore
e, the inflow equired ntal outcomes.	Possible	Moderate Harm	C	Peer review of designs. Designs engineered above capacity of waterway capacity.	Possible	Minor Harm	C	NCCMA, Asset owner / operator	Upp Asse

o expensive to environmental	Rare	Major Harm	C	DEPI and GMW working through process of dtermining delivery charges and tariffs	Rare	Moderate Harm	D	NCCMA, DEPI, GMW	DEP
responsibilities	Rare	Major Harm	C	DEPI to manage process to determine ownership, management, maintenance, operation of structures. Roles to be adequately funded. O&M manuals	Rare	Minor Harm	D	NCCMA, DEPI	Basi man Rep
	Possible	Moderate Harm	C	Design to minimise vandalism. Inspection and maintenance	Unlikely	Minor Harm	D	NCCMA, Asset owner / operator	Con
d volume or nts or high	Unlikely	Moderate Harm	C	Maintenance plan to minimise need for maintenance during operations. Dual gates on most offtakes to allow for continued flow if one is not working	Unlikely	Minor Harm	D	NCCMA and GMW	Con
me, costs, reputation risks)									
bserved post tcomes, the of progress lamage among	Possible	Negligible Harm	D	The Living Murray Hipwell road project has implemented a monitoring program and outcomes have been observed with little time lag. Similar monitoring program to be implemented.	Unlikely	Negligible Harm	D	NCCMA	Hipv
be inadequate environmental lost ve	Unlikely	Moderate Harm	C	Clear and detailed project plan including clearly articulated milestones. Clear documentation of project information and progress. Targeted recruitment process (if required) with clear description of role defintion.	Unlikely	Minor Harm	D	NCCMA	SDL
n that al benefit	Possible	Moderate Harm	C	In-principle agreements with landowners to purchase land for channels if project is funded. Alternate alignments if primary alignments not available. Land valuations conducted so acquisitions to be properly funded. Ongoing engagement with landholders and involvement in channel supply design	Unlikely	Minor Harm	D	NCCMA	Con Lanc Stak In-pi corr
	Rare	Extreme Harm	B	Structures to be designed to be abandoned without impacting on floodplain hydraulics or ecology	Rare	Moderate Harm	D	NCCMA	Con
d, the water watering ssets.	Rare	Major Harm	C	Seasonal watering plan developed by people with much experience of watering these types of forests	Unlikely	Minor Harm	D	NCCMA	Seas Fore

Appendix 5: Hydraulic model development

Model development

The hydrodynamic models for this study were developed using MIKE FLOOD modelling software. MIKE FLOOD has been applied to a range of environmental management floodplain studies in Australia, including major studies for the Gunbower and Koondrook-Perricoota forests located immediately upstream on the River Murray.

Model topography

The topography in the models is formed from a combination of existing LIDAR collected by the Murray Darling Basin Commission (MDBC) in 2001, River Murray cross-sections collected in the late 1970's, and a range of new survey data collected specifically for this study. This new survey includes six new river cross-sections, forest inlet and outlet channel cross-sections and long-sections, survey of the levees between the forests and the surrounding floodplain, and quality assurance survey for validation of the LIDAR data within the forest floodplain.

The modelling schematisation is shown in Appendix X. This shows two separate two dimensional (2D) model grids representing the two forests. These are linked to a one dimensional (1D) river network extending between the Barham and Pental Island Pumps gauging stations, including the River Murray channel and the Little Murray anabranch channel.

The forest topography for Guttrum Forest and Benwell Forest is shown in Appendix X. These figures highlight the location of the permanent and semi-permanent wetland features within the forests and the major flowpaths. The alignment of the levees between the forest and the adjacent farmland is also marked on these figures.

Model schematisation

Layouts of 1D model elements and associated river chainages are shown in for Guttrum Forest and Benwell Forest in Appendix X. The 2D forest grids and the 1D river network are linked by 1D channel elements representing the low-lying inlet and outlet channels from the forests. In addition, for higher river flows the 1D river network and 2D forest grids are directly linked to allow water to spill across the river banks, as well as through the inlet/outlet channels.

The project actually uses two separate models for the Guttrum and Benwell Forests. The Guttrum river/forest model includes the 2D Guttrum Forest model but excludes the 2D Benwell model, and vice versa. This approach was taken as water management measures in the forests are independent, with changes in either forest being very unlikely to affect modelled water levels in the other. This assumption was tested and confirmed during model development by comparing River Murray levels and flows for a full model including both forests against a part model including only Benwell Forest.

Boundary conditions

The model hydrological boundaries are the gauging stations River Murray at Barham (409005) at the upstream end, and the River Murray at Pental Island Pumps (409214) at the downstream end. River flows at Barham are used as an inflow boundary, while the Pental Island rating curve is used as a flow-level boundary.

In addition to topographical and hydrological data, the model also uses a range of meteorological, soil infiltration and storage, and floodplain vegetation data. The application of this data is outlined in the methodology and calibration reports.

Model calibration and validation

Model calibration was carried out in two stages. The first stage focussed on calibrating the 1D river channel model, to ensure that modelled water levels at the internal boundaries between the river and forest inlet channels and banks are accurate This was followed by calibration of the 2D model forest inundation patterns.

1D model calibration and validation

The 1D model component representing the River Murray was calibrated using measured peak water levels from flood events in 1975 and 1991 with peak daily flows of 34,095ML/d and 27,460ML/d respectively. The 1991 flood was a moderately sized event largely contained within the river channel, and this event was used as the basis of the in-bank channel calibration. From this calibration a uniform "Manning's n" value of 0.050 was adopted for the entire length of river channel between Barham and Pental Island. The larger 1975 event produced much more widespread inundation along the floodplain This was used as the basis of out-of-bank floodplain calibration and a "Manning's n" value of 0.10 was adopted for the wider floodplain above river bank level. Both calibrations were able to closely match observed levels, particularly for the smaller 1991 event.

The 1D model was validated against other flood events for which peak levels along the river were available This included events in 1956, 1983 and 2012 which had peak flows of 34,145ML/d, 31,921ML/d and 25,920ML/d respectively. The validation confirmed the calibration, with validation model errors for the 1956 and 1983 events within ± 0.15 metres of observed peak flood levels. The 2012 event validation was poorer as it was affected by a significant change in the rating curve at the Barham gauging station (409005) in 2010. This change in the rating curve is discussed in detail in the Calibration Report, and in the limitations and assumptions section of this chapter.

2D model calibration

Following calibration of the 1D model, the forest floodplain calibration was carried out using satellite imagery available for a long flood event in 2000. The calibrated 1D was combined with the 2D models and run for the length of the 2000 event, and the outputs compared against five Landsat images available at different stages of the flood. In general, the models showed very good agreement with the satellite imagery The five images were taken during different periods of rising, peak and falling river flows, and the model reproduces the movement of the inundation front with changes in river level well.

The Guttrum Forest 2D model grid was found to be sensitive to topographic data error along a tile boundary in the MDBC 2001 LiDAR dataset (see the calibration section below). This boundary runs from southeast to northwest through the middle of Guttrum Forest and along the very south-western corner of Benwell Forest. A comparison against quality assurance survey data collected for this project indicated that the edge of the southern tile is biased towards underestimating ground levels by between 0.1 and 0.3 metres.

Initial calibration model runs for the 2000 event demonstrated that this error does affect the thresholds for flows into Reed Bed Swamp The bias towards lower levels allows too much water into the swamp, overestimating the inundation extent for a given river flow event This was addressed during 2D floodplain calibration by adjusting the grid along the southern side of the grid discontinuity. The adjustment consisted of an increase in DEM levels of

0.25 metres along the length of the discontinuity, decreasing to an increase of 0.0 metres on a parallel line to the discontinuity, running 600 metres to the south. This change significantly improved the 2000 event floodplain calibration.

Limitations and assumptions

The modelling is based on limitations and assumptions that need to be kept in mind when applying the model results and in future of the models. The following issues are highlighted

- Model grid spacing: The 2D models use a 10 metre grid of the forests Finer grid resolution increases model run times, and 10 metres was selected during model development as the finest spacing for which model run times would be acceptable. This resolution places a limitation of the size of feature that can be represented in the 2D model domain. Key forest inlets are represented in 1D to ensure their flow capacity is accurately represented. However smaller river bank and forest features may only be coarsely represented or omitted from the 2D grid.

- Infiltration modelling: A soil infiltration survey (Wrigley Dillon, 2013) was carried out for the project, and the outcomes from the survey were included in the model development. The survey report states that: *the wetland and mid-floodplain areas in the forests will initially have very high infiltration rates; these decrease rapidly to the saturated hydraulic conductivity rate after the first few days; and generally the top ~600 mm of the soil profile will become saturated within the first month of inundation.* Representation of this wetting process is difficult with a hydrodynamic model. However this has been included in the 2D models as lumped soil moisture storage with a capacity (porosity) of 0.17 metres of water per metre depth, surface infiltration rate of 6.3 mm/d, and a saturated leakage rate to lower soil layers of 3 mm/d.
- Evaporation modelling: Historical time series evaporation rates have been applied to the 2D models. Water management option simulations have used evaporation rates suitable to the likely seasonal timing of forest filling events.
- Vegetation effects on flow: The 2D model grids use hydraulic roughness parameters that are fixed in time. This means the vegetation resistance to flow doesn't change in response to wetting and drying of the floodplain, or the growth of vegetation and the resulting increased friction.
- River Murray at Barham (409005) gauging station rating curve: The rating curve at Barham shows a significant shift in the river flow – level relationship between 2007 and 2010. This reflects corresponding changes in the gaugings taken at the site over this period, which for a given water level show a reduction in gauged flow compared to earlier gaugings. The gaugings and the rating for the site had previously been stable with little change since 1990. The reason for the shift has not been conclusively identified, however, the change coincides with a change from current meter to acoustic Doppler (ADCP) gauging measurement technology by the NSW Office of Water. Similar changes have also been seen at other sites in NSW over this period.

The change is large enough to make pre-2010 calibration inconsistent with post-2010 calibration. As a result, the 1D river model overestimates Barham gauging station water levels when post-2010 flows are used as an inflow boundary. For this study the hydrodynamic models use pre-2010 instead of post-2010 flow calibration. This was chosen to make the models consistent with the existing River Murray water resource MSM-BIGMOD modelling which utilises historical series and which has been calibrated to the pre-2010 Barham flow record. As the MSM-BIGMOD flow series are used in conjunction with the hydrodynamic models to determine how often forest inundation occurs, the hydrodynamic model calibration has to be consistent with the hydrological model calibration.

- LIDAR correction: As discussed in regard to the model calibration, there is an error in the LIDAR grid which affects ground levels through the middle of Reed Bed and Guttrum swamps in Guttrum Forest, and river bank threshold levels at the eastern end of Guttrum Forest. After reviewing topographic survey it was decided to apply a correction to the LiDAR to reduce the impact of this error on threshold level for the key flowpath between the two swamps. The correction is based on the quality assurance survey data available at two locations within Guttrum Forest. The accuracy of this correction in other parts of the floodplain is unknown, and this is a source of uncertainty in the modelling.
- G3 regulator: The only existing regulator in the forest is a vertical gate structure located on the G3 inlet channel. Currently this structure is unable to be operated, but is fixed with the gate partially raised.

- Forest inlet and outlet blockages: The forest inlets and outlets may be blocked by natural and man-made features from time to time. Natural features may include vegetation growth, fallen trees, or channel movement or sediment deposition. Man-made features may be temporary structures placed in channels to prevent or reduce inflows to reduce the risk of overtopping of forest boundary levees into adjacent farmland. Such features are thought to have been present during past events but have not been included in the calibration, validation or scenario modelling.

Appendix 6. Concept design report

Provided with supporting documents

URS

Concept Design Report

North Central CMA Sustainable Diversion Limit Projects

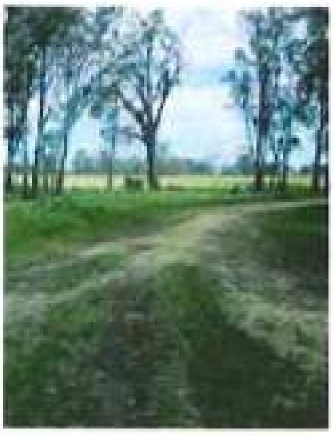
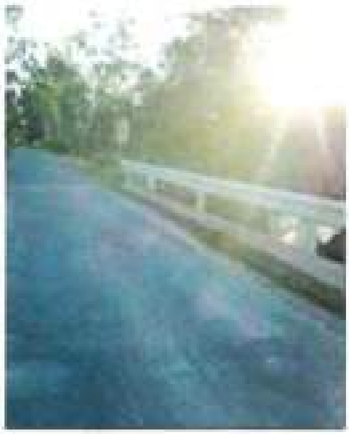
AUSTRALIA

Confirming Concepts for Guttrum and Benwell State Forests

28 November 2014
43260685/01/02

Prepared for:
North Central Catchment Management Authority

Prepared by URS Australia Pty Ltd

Appendix 7: Mitigation options for third-party flood impacts

Approach for Assessing Flood Risk Mitigation Options for Guttrum-Benwell

The *Phase Two Assessment Guidelines for Supply and Constraint Measure Business Cases* require that an assessment of the risks and impacts of proposed measures be undertaken in order to demonstrate that risks will be adequately mitigated. One of the key risks identified for this supply measure is that of potential third-party flooding impacts in situations where levees do not provide adequate protection.

In order to demonstrate that this risk can be adequately mitigated for this proposed supply measure, an informed risk assessment was undertaken (Water Technology 2014a), accompanied by the development of a comprehensive suite of potential risk mitigation options (see Table 2). This assessment was underpinned by scenario-based hydraulic modelling (DHI 2014a, Water Technology 2014b) and levee condition assessments (DHI 2014b, Water Technology 2014c). The hydraulic modelling reports and the risk assessment were reviewed by the Expert Review Panel for Victorian supply measure business cases and determined the process and work undertaken to be fit for purpose.

The risk assessment (Water Technology 2014) indicated that the risk of levee failure varied considerably depending on location. Potential mitigation options are aimed at both reducing the likelihood of levee failure/overtopping and minimising consequences or avoiding litigation if a levee failure/overtopping did occur. Table 1 provides a summary of the mitigation options that will be further investigated for their implementation viability during the detailed design phase (i.e. post-business case submission). It is anticipated that potential mitigation options will be assigned to each risk category (e.g. low/moderate/high/extreme) at this time.

Table 1: Potentially Viable Mitigation Measures for Further Consideration.

Option Aim	Mitigation Options
To reduce the likelihood of failure/overtopping	• Levee upgrades • Levee maintenance* • Monitoring levee condition • Manage rates of rise /drawdown during watering
Minimise consequences if failure/overtopping occurs	• Emergency response procedure • Communications plan • Upgrade existing management to provide mitigation • Raise access roads and tracks
Avoid litigation if failure/overtopping occurs	• Landholder agreements • Floodway easements

*Note that levee maintenance can be enabled in a variety of ways however all require permits under relevant legislation.

In presenting the risk assessment in this business case, it is noted that key policy matters that will inform the final risk management strategy for this proposed supply measure cannot be formally determined at this time. This includes any final decision-making on which mitigation options will be selected for implementation.

DEPI will be in a position to provide more formal advice on the state's preferred long-term risk mitigation arrangements for this supply measure once the full suite of Victorian proposals under the SDL adjustment mechanism has been more definitely scoped. This will occur as early as possible in 2015.

Table 2: Mitigation options (full list)

Mitigation Options	Advantages and Disadvantages	Impact on outcomes[1]	Viability
1. Options that reduce the likelihood of levee failure/overtopping			
a. Levee upgrades Upgrade levees as required to ensure a minimum freeboard of 200 mm for managed floods provided across all levees. This option would target areas of high and extreme risk. Preliminary cost estimates for Guttrum-Benwell have a combined cost estimate of $2.5m (plus additional 50% contingency costs). These 'ballpark' costs are just for basic earthworks, the total cost would include significant additional costs for permits, cultural heritage, native vegetation offsets, engineering costs of regulating structures, which is why an additional 50% contingency costs has been added. The works themselves are straightforward but may be problematic with regard to access, approvals and landholder agreements. Some additional works (e.g. regulators) at waterways and irrigation channels are more complicated and will require detailed engineering design.	**Advantages** • Would reduce high and extreme risk areas to medium/low risk. **Disadvantages** • Site access and approvals need further investigation and could be problematic. • Ongoing maintenance program would also be required. • Would require clear asset owner. • Would not prevent legal action if failure did occur.	No	Viable. Essential to implement as a minimum as condition assessment has identified a number of areas where levees would be overtopped during managed watering event (i.e. crest is below level of managed watering event).
b. Levee maintenance Regular maintenance carried out to improve levee condition over time. This option would target areas of low to medium risk. The maintenance program would be based on inspections and monitoring (linked to option 1c below). The estimated annual cost is around $200k. There needs to be consideration of the mechanism to enable such maintenance for levees located on Crown land and who would fund and carry out maintenance. As such, this option links to option 3 below.	**Advantages** • Would maintain risk at medium/low levels • Anticipate that overall levee condition would be improved over time • Would establish a working relationship with landholders and provide a tangible benefit **Disadvantages** • Site access and approvals need further investigation and could be problematic. • Would requires a dependable annual funding source • Could increase liability depending on who carries out maintenance • Could create a perception that the levees are owned by government.	No	Viable. Considered essential as condition assessment has identified numerous high points of weakness at high risk of failure.
c. Monitoring levee condition Regular monitoring of levee condition would be carried out to identify arising issues. Information would be used to target levee upgrades and maintenance. Inspections would be visual and carried out largely on foot. Ideally, partnerships	**Advantages** • May identify new weak spots before they become major issues, minimising maintenance costs. Can track progression of known weak spots so that maintenance/replacement can be targeted to avoid breaches occurring.	No	Viable. An essential due diligence activity and required complement

would be developed with landholders to gain access as needed and share the responsibility for managing the risk of levee failure. An auditable record of inspections/monitoring data would need to be maintained, which will have associated costs not captured below. The monitoring would include annual condition inspections, monitoring during watering events and ad hoc inspections by landholders. Event-based monitoring would require installation of gauge boards (estimated cost $50k). Annual cost estimates for monitoring are set out below: • Annual inspections (based on a rolling program of 20 km/year) - $5k • Event-based Monitoring / Post-flood Inspections - $16k • Landholder Monitoring - $5k	• Involving landholders in monitoring program will build relationship and trust. • Opportunity to incorporate landholder monitoring into routine fence monitoring to avoid placing additional burden. • A low cost way to assist in managing risk, when implemented with other options. **Disadvantages** • Visual monitoring will not necessarily identify all weak spots as piping failures can occur without warning. • Event based monitoring will not necessarily provide sufficient watering time to take preventative action. • Access will be difficult in places and good OH&S procedures will be required. Note that there would be associated liability issues to consider if landholders formally carry out inspections. • A comprehensive monitoring program will require access to private land. • Would require a dependable annual funding source. • Monitoring/inspections will be time consuming.		to levee upgrades/maintenance.
d. Manage rates of rise and drawdown during watering events Rates of rise and drawdown would be managed to reduce levee degradation during and after watering events. This may reduce the risk of bank slumping post inundation.	**Advantages** • Could reduce the rate of levee degradation. **Disadvantages** • May have implications for management of fish movement cues; further consultation with fish ecologists is needed.	Minimal	Viable.
2. Options to minimise consequences if levee failure/overtopping does occur			
a. Emergency response procedure A clear procedure or decision tree would be developed to guide emergency response in the event of a levee failure, including a communication protocol to enable adjoining landholders to take appropriate steps to prevent/reduce damage. The procedure would include determining whether to cease water delivery and whether emergency works or other actions are needed. The response would aim to minimise impacts on adjoining landholders and set out clear roles and responsibilities in the event of an emergency situation. Further consideration of the nature of any emergency works and the potential impacts on surrounding landholders is needed. Any work that redistributes flood waters could place the parties involved at high risk of legal action. Emergency works would also need to be linked with a monitoring program. Consultation is needed with landholders and emergency response agencies is needed to develop this option further (Emergency Management Victoria, Vic	**Advantages** • Planning should reduce response time and likely consequences in the event of a breach. • Clear roles and responsibilities should reduce tension with landholders in the event of a breach. • May provide timely warning to adjoining landholders to enable them to take appropriate action in the event of a breach. **Disadvantages** • It may not be feasible to implement emergency works in practice, depending on the access required. • The time between detection of a breach and notification may not be sufficient for landholders to take appropriate action.	No. If a watering event is interrupted, impact would be on single event only rather than overall outcome.	Viable. Considered essential.

Police, VicSES, Council MERO, G-MW). This option may need to be built into the relevant Municipal Emergency Plan. Consideration of the links with or implications of the Victorian *Emergency Management Act* 2013 is also needed.	• Potential conflict with existing emergency management procedures for natural disasters.		
b. Raise access roads and tracks This option would involve raising potentially flooded roads and tracks to maintain access to houses and other infrastructure in the event of a levee breach. Further analysis of this option is needed to determine the impacts on flood flows and develop cost estimates.	**Advantages** • Landholder access maintained in the event of a levee breach **Disadvantages** • Potential impacts on flood flows leading to unforseen impacts elsewhere.	No	Viable. Considered a secondary option as should not be needed if levees can be upgraded/maintained to prevent flooding.
3. Options to enable levee maintenance			
a. Reserving relevant land This option involves changing the status of part of the Crown land, so that it may be reserved under the *Crown Land (Reserves) Act 1978* (CLRA), allowing for the subsequent appointment of a committee of management (CoM) comprising neighbouring landowners. The CoM must manage the reserved land in accordance with the CLRA. Specifically, section 15(1)(a) of the CLRA provides that a CoM shall manage, improve, maintain and control the reserved land for the purposes for which it was reserved, whilst s15(1)(c) enables the CoM to carry out works and improvements on the land. By maintaining levees on Crown land this option would reduce the likelihood of flooding occurring.	**Advantages:** • Would require reclassification of relatively small areas of land; unlikely to significantly impact on existing uses (e.g. forestry, grazing licences, bee-keeping). • If the neighbouring landowners agree to form a CoM they may manage the reserved Crown land for the purpose for which it was reserved, on behalf of the State, and would have the power to maintain levees on that land (provided it falls within the reservation purpose). **Disadvantages:** • This option does not prevent someone from suing the State if flooding did occur, however we could make a case for contributory negligence • It would need to be very clear which land is to be reserved. As each of the Gunbower National Park and the Guttrum-Benwell State forest already has a distinct status, the land to be reserved would need to be surveyed, and then excised from the Gunbower National Park[2] and/or the Guttrum-Benwell State forest as the case may be. This can entail a lot of work and cost. • The neighbouring landowners cannot be compelled to form a CoM and work together cooperatively. CoMs perform their work as volunteers and are not paid a salary. DEPI may need to fund a CoM to undertake its land management work. • The State through DEPI indemnifies CoMs and their members from liability. Thus, DEPI will not be able to completely avoid costs and liability by following this option. • This option would allow the construction of levees on Crown land, but does not address the issues of the State's liability for inundation of the	No	Not viable. A roundabout option that would have the same outcome as using the new levee maintenance permit system.

[2] This may require a legislative amendment

	Private Land, nor how landowners can be required to construct and maintain levees on the Private land.		
b. Water Management Scheme Under s213 of the Water Act 1989 (s400 of the *Water Bill 2014*) the Minister may arrange for schemes to improve the management of waterways, drainage and floodplains to be prepared and implemented. Water management schemes are typically implemented by CMAs or water corporations, and occasionally municipal councils. Note that a municipal council must first agree to be responsible for implementing a scheme however a CMA or water corporation must implement the scheme if nominated. The *Water Act* (s216) provides for the water corporation or CMA to impose fees or tariffs or fees on the area benefitted or affected by the scheme, or to require contributions from other councils or authorities to fund the scheme. This option would involve the development of a cooperative arrangement to maintain levees to reduce the likelihood of flooding occurring.	**Advantages:** • Maintenance would be funded by those within the area affected (i.e. beneficiaries) if fees/tariffs were imposed, rather than requiring an external funding source. • The CMA could be directed to contribute funding, this could provide a way for the project to contribute to levee maintenance costs. **Disadvantages:** • It is not clear whether Water Management Schemes extend to levee maintenance. • There are no mechanisms set out in the *Water Act* for enforcement. • DEPI would only participate in a Scheme in the sense that it advises the Minister for Water. It is not clear how how or whether DEPI could make any financial contribution be involved with regard to funding maintenance.	No	Not viable. There are a number of unknowns and issues requiring clarification. Would have same outcome as using the new levee maintenance permit system.
c. Levee maintenance permit Under s84AA8 of the *Water Amendment (Flood Mitigation) Act 2014* landholders or agencies may obtain a five-year permit to carry out maintenance on a levee that is located on Crown land (effective from 1 March 2015). DEPI is in the process of applying for associated exemptions from native vegetation offsets and FFG Act permits for removal of non-threatened species. This option provides for landowners to maintain levees on Crown land and manage their own flood risk, or for a centrally managed maintenance program to be implemented by an agency (e.g. CMA). Funding could be contributed to the maintenance program by the project via a funding agreement between a representative of the State and the recipient. The agreement could provide for the recipient to indemnify the state for any loss/damage incurred as a result of the recipient's use of funds. This option may be feasible when minor maintenance on the levee would reduce the likelihood of third party impacts.	**Advantages:** • Landowners may opt to maintain levees themselves without additional funding to mitigate their existing natural flood risk. • An agency-managed maintenance program could be attractive to landholders, particularly if funding can be secured. **Disadvantages:** • This is a permit based option, each time the permit expires or a land title changes hands there is no certainty as to who (if anyone) is maintaining the levee. • Maintenance will only occur if landholders see a need (i.e. wants to repair a levee) • Would require an inspection program to ensure the works are carried out to a suitable standard. • Potential liability for the State remains as the *Water Amendment (Flood Mitigation Act) 2014* is silent on liability.	No	Viable. Would only apply to levees are on public land.
d. *Conservation, Forests and Lands Act 1987* Section 69 allows for an agreement to be made between the Secretary and a landowner regarding the management, use, development, preservation or conservation of the land or otherwise for the purposes of giving effect to a relevant law, for example the *Flora and Fauna Guarantee Act 1988*. This option would involve the development of an agreement to reduce the risk any third party impacts by:	**Advantages:** • Such an agreement can restrict access/activity/land use (s70). • The agreement is binding on the landowner's successors in title. • Provides for a funding agreement which could negate the possible land devaluation. • Would indemnify DEPI's Secretary.	No	Viable. Would only apply to levees on private land.

• Ensuring that private land at risk of flooding was not used during a managed flood event; and/or • Levees on private land are maintained and not removed. • Requires the land owner to obtain insurance to indemnify the Secretary against specified activities in relation to the Private Land, to insure against liabilities and actions in tort in relation to the Private Land and to obtain other forms of insurance or assurance that are specified in the agreement[3]; • Requires the Secretary to provide the land owner with advice, financial or other assistance including compensation for loss of income arising out of the performance of the agreement.[4] Additionally, this option could be used to allow flooding to occur without third party impacts if the agreement specifies that a certain area of the land will not be used by the landowner.	• Can be a fast and simple process and can be tailored to the specific requirements of the project(s). **Disadvantages:** • The circumstances may not match the purposes of a s69 agreement. It is unlikely that a s69 agreement can be used solely to avoid liability for the inundation of the Private Land • It is unclear if third parties (i.e. other than the DEPI Secretary) can be indemnified. • The area covered by the agreement may be extensive and may include houses, roads and other infrastructure. In such cases, this option would need to be used in combination with other mitigation options. • Likely to require on-going funding to be made available to continue to pay landowner in consideration of any on-going repair and maintenance work required under the agreement or any restrictions on the owners of the Private Land.		

e. ***Planning and Environment Act 1987***
The 'responsible authority' (in this case the relevant municipal council) can enter into an agreement with a private landowner (s 173 Agreement) under s 173 of the *Planning & Environment Act 1987* to[5]:
• prohibit, restrict or regulate the use or development of the Private Land;
• set out the conditions subject to which the Private Land may be used or developed for specified purposes;
• any matter intended to achieve or advance:
  o the objectives of planning in Victoria; or
  o the objectives of the planning scheme; or
• any matter incidental to any one or more of the above matters.
This option can be used to both reduce the likelihood of a flood occurring and to enable flooding to occur without the threat of third party impacts.
	Advantage:
	• In the current circumstances, it could be argued that a s 173 Agreement could be entered into that sets out the conditions around the use and development of the Private Land, for example requiring the construction and maintenance of levees on that land.
	• Other parties (eg the Secretary or the CMA) may also be a party to such a s 173 Agreement.
	Disadvantages:
	• It is the State that requires control over the Private Land in order to flood it without liability. However, it is the municipal council as the responsible authority that is empowered to enter into the s 173 Agreement. Although the State through DEPI or the Secretary could also be a party, ultimately this would depend on the municipal council's willingness to participate.
		No	Viable.
			Could be used for levee maintenance or other flood protection works on private land.

f. **Funding agreements with third parties** This option would enable the State through DEPI to provide funding to an owner of the Private Land, to undertake specified works on that Private Land, or on a specified parcel of Crown land. The agreement would link funding payments to the achievement of specified milestones, such as obtaining advice on the location of levees, obtaining any necessary planning approvals, maintaining a levee, and	**Advantages:** • Allows landowners to decide how best manage their own flood risk and provides some funding to enable them to do so. • This is quick and straightforward process. **Disadvantages:**	No	Viable. Could be used for levee maintenance or other flood protection works on private land.

[3] s 70(1)(j) CF&L Act
[4] s 70(1)(k) CF&L Act
[5] The purposes of a s 173 Agreement are set out in s 174 of the *Planning & Environment Act 1987*.

undertaking regular inspections. This option would allow landholders to protect themselves from the potential impacts of flooding by building ring levees around infrastructure or raising an access track. Funding agreements would need to specify the necessary works. An inspection program to ensure the works are carried out to a suitable standard to support payment against milestones.	• Landowners cannot be compelled to accept such funding or to enter into the agreement. • Whilst a funding agreement may provide that the funding recipient will indemnify the State for loss or damage arising from the performance of the agreement, this will not cover all foreseeable losses (e.g. if inundation of Private Land occurs despite the levee works having been undertaken). • A funding agreement will endure for so long as there is funding. It cannot bind future owners of the Private Land. • This option is likely to provide only a partial solution and needs to be implemented in tandem with other options. • If it is established that the levee system cannot be maintained to an adequate level to prevent third party flooding impacts funding agreements will not be the best use of funding.		
4. Options to provide compensation if damage does occur			
a. Compensation fund This option would establish a fund from which impacted third parties can be compensated for damage to land and/or property from a managed flood event. This option would manage residual risk. There is no legislation that specifically deals with this kind of scheme. The fund would need be supported by robust policy to specify the circumstances in which DEPI will pay all or a set proportion of the costs of replacement or reinstatement as the case may be. DEPI may also pay for some costs of lost hay and fodder after flooding The policy has limited application and requires claimants to fill out a form, which will trigger an inspection and evaluation of the claim. DEPI would either pay for the landowner to arrange for replacement/reinstatement works or DEPI would undertake this work. If DEPI pays the landowner, the landowner is required to enter into a simple funding agreement before payment will be made. This agreement includes a release and indemnity provision, by which the landowner agrees not to pursue DEPI further for costs in relation to that damage. DEPI's Land, Fire and Environment Group have established a similar fund to pay for the rebuilding of fences after a fire.	**Advantages:** • Would minimise litigation against the state government; impacted third parties could apply for compensation according to the funding scheme rules . • Minor damage would be quickly and simply dealt with. Affected landowners who may otherwise be disgruntled by the damage caused by the watering could be satisfied with swift reinstatement and repairs, having a positive reputational impact. **Disadvantages:** • The body responsible for the flooding will accept liability. This does not address reputational risk. • Funding needs to be available to support this policy. • Human resources will need to be allocated to administering such a scheme.	No	Not viable. Would require ongoing administration and funding.
5. Options to enable flooding			
a. Floodway easement This option involves acquiring flood easements by agreement over potentially inundated land from adjoining landholders, thereby preventing the likelihood of	**Advantages:** • Effectively mitigates the risk of litigation, provided that no flooding occurs outside easement boundaries.	No	Viable.

third party impacts. An easement generally decreases the value of the land it is on. Determining the area needed to be covered by the easement will require reliable hydraulic modelling. Easement purchase involves a single payment and easements are registered on the land title and do not need to be renegotiated if the land changes hands. Any purchase would need to be made by an entity with a statutory right to acquire interests in land. The DEPI Secretary has the power under the CF&L Act to purchase an interest in land for the purposes of the Act. Easements could also be acquired by Goulburn-Murray Water. The MDBA does not have the power to acquire interests in land in Victoria.	• Registered on title. • Enables registered owners to be compensated for loss of use of private land. • Landholders still have access to their land and can take additional steps to manage their flood risk. • More cost-effective than purchase as easement cost is a percentage of the total valuation **Disadvantages:** • Timeframes and requirements of *Land Acquisition and Compensation Act 1986* must be adhered to. • Need to pay for easement acquisition. • Viable when only a relatively small part of a property is at risk of flooding; if a large proportion was at risk, the property devaluation would be considerable and landholders unlikely to agree. • Actively pursuing easement acquisition can be viewed as aggressive; reputational impact. • Cannot protect the CMA from liability.		
b. **Land purchase** Requires an acquisition by agreement of private property (or subdivision and purchase of part property). This option would enable flooding to occur without the risk of third party impacts. Any purchase would need to be made by an entity with a statutory right to acquire interests in land. The Minister is able to purchase land under the *Land Act 1958*, *Land Acquisition and Compensation Act 1986* (LACA) and the CF&L Act Under s 18 of the LACA an acquiring authority can, having initiated the land acquisition process under a special Act, enter into an agreement with the landowner, rather than completing the compulsory acquisition process). No amendment to the planning scheme and no notice of intention to acquire are needed. Instead, the acquiring authority would, once the terms of the acquisition have been agreed with the registered owners of the Private Land, serve a notice of its intention *not* to acquire the land. Such a notice stays in force for 12 months. This option would involve making offers to adjoining landholders to purchase some (areas potentially flooded) or all of their properties, or opportunistic purchase of any properties that were put up for sale in the future. Unless whole parcels were purchased, subdivision of private land would be required (ideally to maximum inundation extent) and the area purchased would only be of the area that could be flooded.	**Advantages:** • Effectively removes the risk of third party impacts. • Could be undertaken opportunistically in tandem with other mitigation options. • Enables registered owners to be compensated for loss of use of Private Land. • Compensation can be given to owners of privately held land. **Disadvantages:** • Acquisition could be quite costly. • Would need to put ongoing management arrangements in place and provide funding. • The timeframes and requirements set out in the LACA must be adhered to, which can add to the time and complexity of negotiations. • This option is dependent on the willingness of the registered owners to negotiate with the acquiring authority.	No	Viable.

NOTE: Options 3d and 3e could also be used to enable flooding	

Supporting Documents

List of documents submitted with the Business Case.

ACHM 2014, *Aboriginal Cultural Heritage Assessment- Guttrum and Benwell State Forests*

Biosis 2014, *Flora and fauna assessment of the Gunbower National Park and Guttrum and Benwell State Forests*

Biosis 2014, *Mapping and Condition Assessment of the Guttrum and Benwell Forests*

Cummins, J and McGrath, S 2014, *Gunbower National Park Business Case level Engineering Review*

Department of Environment and Primary Industries 2014, *Basin Plan Environmental Works Program: Regulatory Approvals Strategy*

DHI 2014, *Applying modelling tools to investigate water management in the Guttrum and Benwell State Forests – Calibration Report*

DHI 2014, *Applying Modelling Tools to Investigate Water Management in the Guttrum and Benwell State Forests – Methodology Summary Report*

DHI 2014, *Applying Modelling Tools to Investigate Water Management in the Guttrum and Benwell State Forests - Water Management Option Modelling*

DHI 2014, *North Central CMA Guttrum Benwell levee failure modelling*

DHI 2014, *North Central CMA* Modelling for Murray Wetland Forests- Operational Water Scenario Modelling

Ecological Associates 2014, *The Ecological Justification for Works and Measures for the Guttrum and Benwell State Forests*

Gippel, CJ 2014, *Peer Review of Hydraulic Models for Guttrum-Benwell Forests- July 2014*

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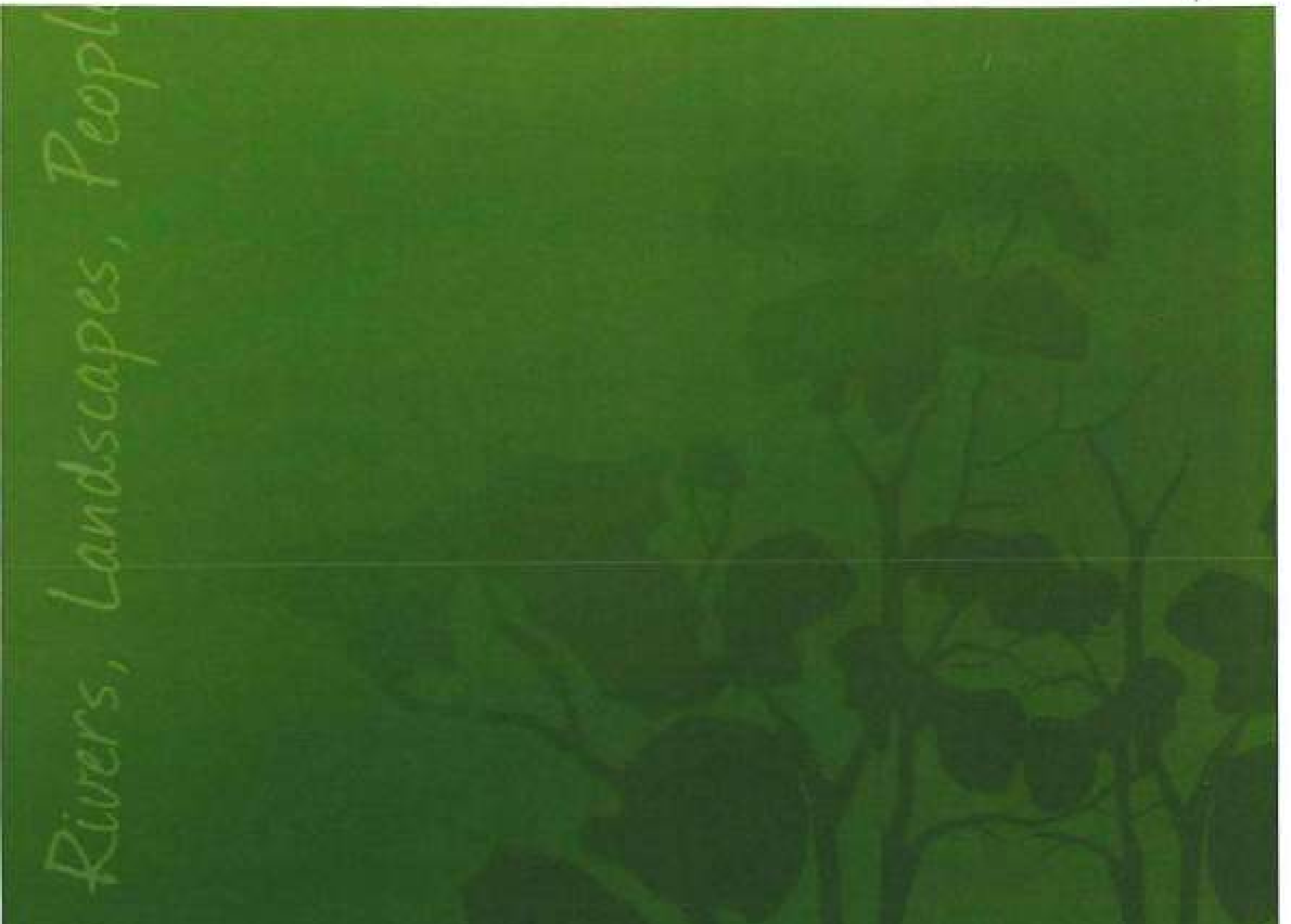

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