

**FINAL REPORT**

Lake Mokoan Study

Executive Summary



*Prepared for*

**Goulburn Broken Catchment Management Authority**

*By*

**URS**

August 2003

# Foreword

The final Lake Mokoan report represents a major body of work which addresses options for the future management of Lake Mokoan.

It consists of three volumes:

Volume 1: Situation Analysis

Volume 2: Option Assessment

Volume 3: Community Response

These are accompanied by a stand-alone Executive Summary

The report builds on the Interim Report and the study “Water savings in Bulk Water Systems in Northern Victoria” (March 2002) prepared by Sinclair Knight Mertz (SKM).

Volumes 1 and 2 will be on exhibition for 6 weeks. Public submissions close on the 19th September, 2003. These submissions will be collated to form Volume 3. The Minister will then be presented with all three volumes.

The options addressed in Volume 2 of this Report were selected from an extensive range of alternatives through a collaborative approach involving the Reference Committee and the broader community. The Report analyses each of the identified options according to establish economic, environmental and social criteria relating to Lake Mokoan in a local and catchment context.

The Steering Committee will not be recommending a preferred option to the Minister. It is not possible to determine the most effective option because of the benefits that may accrue outside the Broken River Catchment. These benefits were not canvassed in the study because they are being addressed in the Goulburn environmental flows study and the Living Murray study.

The Victorian Government has committed itself to a target of reducing system losses by 25 per cent. Lake Mokoan has the potential to deliver a significant percentage of these savings.

I would like to acknowledge the role of the Reference Committee ably led by Huw Davies. The Reference Committee has played a critical role in channelling information from the community to the Steering Committee and back again.

I would also like to acknowledge the intensive efforts of the Steering Committee and in particular the Project Manager Bill O’Kane. The Steering Committee was ably assisted by the Consultants URS, who have been rigorous in their analysis and flexible in their dealings with community input.

I strongly urge people to consider this report carefully and make a submission.

Kevin Ritchie

**Chair**

**Lake Mokoan Study Steering Committee**



# Acknowledgments

The team of consultants for the Lake Mokoan Study was drawn from URS Australia Pty Ltd, GHD Pty Ltd, Ecos Environmental Consulting Pty Ltd, Group Strategies Pty Ltd, and TerraCulture Pty Ltd Heritage Consultants.

The consultants wish to express their appreciation for the assistance and guidance provided by the Steering Committee for the project. The Steering Committee comprised:

Kevin Ritchie, Department of Sustainability and Environment (Chairman); Huw Davies, Chairman of the Lake Mokoan Reference Committee; Graeme Turner, Department of Sustainability and Environment; Geoff Earl, Goulburn-Murray Water; Ian Howley, Goulburn-Murray Water; Robert Dobrynski followed by Matthew Nelson, Shire of Delatite; Tony McLeod, Murray-Darling Basin Commission; and Bill O’Kane, Goulburn Broken Catchment Management Authority (Project Manager).

The consultants also express their thanks to members of the Lake Mokoan Reference Committee for their diligence and cooperation. The Reference Committee comprised:

Huw Davies (Chairman, Ministerial appointment); Richard Anderson, Gravity Irrigation Water Services Committees; Bruce Anderson, Manager Operations, Goulburn Valley Water; Doug Bain, Save Lake Mokoan Working Group; Rod Berger, Field and Game Association; John Boal, Country Fire Authority, Wangaratta; Maureen Cottam, Victorian Farmers Federation; Bernie Evans, VR Fish; Neville Fowler, Manager, Fisheries Victoria (Northern); Ray Henderson, Broken River Water Services Committee; Monica Morgan, Chair, Yorta Yorta Nations; Michael Reid, Save Lake Mokoan Working Group; Sally Simson, Mid-Goulburn Broken Implementation Committee; Stuart Fraser, Environment Victoria; Ken Whan, Delatite Shire.



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## **1.1 Background**

The demand for water in northern Victoria, both for new development and environmental needs, continues to increase. The introduction of the Murray-Darling Basin Cap prevents additional water being diverted from streams in the Basin. There is, however, potential for further development and for increased environmental flows through improved efficiencies in water storage and delivery. In the study *Water Savings in Bulk Water Systems in Northern Victoria* (March 2002), Sinclair Knight Merz (SKM) concluded that the best opportunities for potential savings were associated with Lake Mokoan.

SKM identified three options for changing Lake Mokoan to achieve water savings, namely:

- revert the lake back to the original natural wetlands;
- reduce the size of the lake by constructing a partition and operating the lake under existing rules; and
- reduce the size of the lake and operating it as an annual water storage facility.

## **1.2 Scope and purpose of the Lake Mokoan Study**

The objectives of the Lake Mokoan Study are to determine the feasibility of each of the identified options to change Lake Mokoan and to provide Government with sufficient information to make a decision about the future of the lake.

The Study was undertaken in the context of seeking the best solution to three current problems associated with Lake Mokoan, namely:

- water loss from evaporation;
- poor water quality; and
- the costs of operating the lake and the equitable sharing of those costs.

The Study considered the options from the perspectives of:

- the operation of the water supply system extending from Holland's Weir to the Torrumbarry System, including the associated waterways and potential integration with the Murray System;
- relevant socio-economic uses and impacts on the local and wider community; and
- effects on the environment in the immediate vicinity and elsewhere.

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### **1.3 Implications of the Study for the Murray River**

Lake Mokoan has the potential to provide additional operational flexibility to the management of flows in the River Murray System. Therefore, the Murray-Darling Basin Commission (MDBC) has a specific interest in the future of the lake, as well its general interest in the management of natural resources in the Murray-Darling Basin. Furthermore, under Clause 46 of the Murray-Darling Basin Agreement proposals that may significantly affect the flow, use, control or quality of water in the River Murray System need to be referred to the Commission for consideration and possible representation to Governments. For these reasons, it is important to note that there are other initiatives under way to investigate potential changes to the operating regime at Lake Mokoan, with reference to the River Murray.

The Living Murray initiative (<http://www.thelivingmurray.mdbc.gov.au>) of the MDBC is aimed at improving the health of the River Murray. In July 2002, the Murray-Darling Basin Ministerial Council stated that:

*In addressing the environmental needs of the River Murray, the tributaries will have to play their part in providing adequate flows. This will involve the Murrumbidgee and Goulburn Rivers and, although the contribution to the Murray is smaller, the Darling River above Menindee Lakes. There will be environmental benefits achieved for the tributaries as well as the River Murray through this process. ('The Living Murray – a discussion paper on restoring the health of the River Murray', page 1.)*

Accordingly, the Living Murray initiative includes a joint study in 2003 between Victoria and the MDBC of the potential for the Goulburn-Broken River System, including Lake Mokoan, to contribute to environmental flows in the River Murray System. The information generated through the Lake Mokoan Study will thus be relevant to the Living Murray initiative. The outcomes of the Lake Mokoan Study are being monitored by both these initiatives.

### **1.4 Lake Mokoan**

Lake Mokoan is an off-river storage in the Broken River valley near Benalla. It was formed by the construction of an embankment (approximately 7.5km long and averaging about 6m high) to inundate a series of wetlands, the largest being Winton and Green Swamps. The creation of the storage also inundated Ashmeads, Taminick, Lindsays, Humphries, Saddlers and Black Swamps.

Lake Mokoan together with Lake Nillahcootie, which is on the Broken River upstream of Benalla, were constructed in the late 1960's. The prime function for Lake Mokoan was to be operated in conjunction with Lake Eildon and Lake Nillahcootie to be operated for the regulation of flow of the Broken River to meet stock, domestic and urban requirements throughout the Broken River valley. Lake Mokoan has a capacity of 365,000ML, a surface area of about 7,880ha and a maximum depth of 7.3m and, due to the relatively small local catchment area (330km<sup>2</sup>), was required to have an inlet channel (2,400ML/d capacity) from the Broken River. Lake Nillahcootie has a capacity of 40,200ML. An outlet channel constructed along Stockyard Creek, following the natural drainage line, conveys water back to the Broken River above Casey's Weir.

### **1.4.1 Dam Safety Issues**

A recent risk assessment for eight of G-MW's storages, determined that the principal dam safety issue at Lake Mokoan is the risk of piping of the dispersive clay embankment. Piping could be initiated by upstream slope failure, earthquake induced cracking or historic high reservoir level seepage through unknown cracks.

The assessment concluded that the storage presented an intolerable risk to G-MW due to the high societal risk with failure. This was a result of the potentially high loss of life due to the close proximity of the ADI munitions factory to the embankment.

### **1.4.2 Lake Mokoan Operation and Maintenance Costs**

The total annual cost of operating and maintaining Lake Mokoan in 2001/02 was \$676,000, comprising total direct costs of \$526,000 and total indirect costs of \$150,000. In addition to the G-MW recurrent annual costs for operating and maintaining Lake Mokoan, the Department of Sustainability and Environment spends a further \$54,000 per year on fish stocking, legislative compliance management and research.

### **1.4.3 Water Supply**

The customer entitlement supply commitment in the Broken River system to be met from Lake Nillahcootie and Lake Mokoan is 32,277ML. In addition to the entitlement commitment, the storages must meet non-supply commitments. These commitments comprise operational loss, river (transmission loss and storage evaporation loss). The total water lost from the Broken River supply system could, therefore, be as high as 130,000ML, two-thirds of which is evaporation from storages.

As a result of the problems with the water quality in Lake Mokoan and the efforts taken to improve the water quality, constraints have been placed on the filling and depletion of the lake. In determining the Broken River system allocation, the rise and fall of the storage is limited to 1.5m in each direction within any 12 month period. Because of the difficulty in predicting actual evaporation the actual fall in the storage level may exceed 1.5m.

## **1.5 Current Environmental Situation**

### **1.5.1 The Lake**

After commissioning in 1970 and until 1982, water clarity in Lake Mokoan was considered to be good and the lake contained abundant beds of submerged macrophytes. Blue-green algae were not considered a problem during this period. During the 1982/83 drought the storage was drawn down to only 4 per cent of capacity. Stock were also allowed to graze on the exposed vegetation around the lake shoreline. The lake was refilled rapidly in 1984, then drawn down again and kept at a low level until 1986. After these

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major water level fluctuations, turbidity increased dramatically, nutrient levels increased and the lake vegetation did not recover. Since 1989, large blooms of toxic blue-green algae have occurred in most years and due to the resulting decline in water quality, have severely curtailed the use of lake water for water supply and recreational purposes.

Previous lake water level management, the orientation of the lake's long axis with the direction of prevailing southwesterly winds, and other factors have contributed to the high turbidity of the lake's water. Shear stress modelling for Lake Mokoan has identified sediment re-suspension as the result of shear stresses imparted by wave action to be the primary source of turbidity in the lake. Modelling results indicated that sediment shear stress varied with storage capacity and wind strength. However, high shear stress areas occurred in the north east corner of the lake for all scenarios modelled, even at lower wind speeds.

In response to on-going water quality problems, regulated outflows from the lake have been limited to an average of 22,000ML/year and lake levels limited to a maximum 1.5m rise and fall within any 12 month period in an effort to promote vegetation growth in and around the lake. In the last 9 years, Lake Mokoan has been operational all year only in 1997/98. The limits on lake level variability have led to declines in turbidity although it is not certain if these improvements will continue or will be limited by negative feedback mechanisms, such as disturbance of the lakebed by carp.

The lake currently supports a good recreational fishery based mainly on stocked Golden Perch with some Murray Cod. The lake also supports abundant waterbirds including several duck species. Duck hunting is also a popular activity.

The fact that Lake Mokoan once existed in a desirable non-turbid and vegetated state shows that such a stable configuration is possible for the lake. The key to water quality improvements is the re-establishment of the lake's submerged and shoreline vegetation which is expected to out-compete blue-green algae for nutrients.

### **1.5.2 Downstream Environmental Effects**

The key downstream environmental effects of Lake Mokoan are the change in river flow regime and the change in river turbidity in the lower Broken River and the Goulburn River. The modelling results show that the key impact of Lake Mokoan on the river flow regime on the lower Broken and Goulburn rivers is the difference in the magnitude of flow. The current management of Lake Mokoan producing average monthly flows over winter and spring which are around 10,000ML (or more) less than the original situation when wetlands occupied the area. The effects of Broken River flows in the Goulburn River are greatly masked by the much greater flows coming from the Goulburn River Catchment.

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***River Turbidity***

When highly turbid water is released from Lake Mokoan (generally in spring/summer), the turbidity of the Broken River downstream is significantly increased. Discharges from the Broken River to the Goulburn River then result in increased turbidities in the Goulburn River, although to a lesser extent. Higher turbidities may be expected to reduce production of aquatic plants with flow-on impacts to the food chain. Originally, Winton Swamp rarely discharged (only in Spring of some years), and the turbidity of discharge would have been much lower as the wetland was well vegetated and had a smaller surface area (and thus calmer waters due to reduced fetch for wave buildup) than Lake Mokoan.

The current management regime for Lake Mokoan has produced a slow decline in average turbidities. One of the contributing factors for this is considered to be the maintenance of high water levels (between 42 per cent and 70 per cent of FSL). With current management practices it is expected that this decline in turbidity will continue but the extent is not known. It is possible that a new equilibrium may be reached where turbidities stabilise at a lower, but still relatively high level. Further intervention may then be required to achieve lower turbidities and decreased frequencies and durations of algal blooms.

**1.6 Current Heritage Situation**

Although there has been no assessment of Lake Mokoan itself, there has been a relatively large amount of archaeological investigation in surrounding areas, particularly to the north of Benalla and in the Warby Range. This has been mostly concerned with investigations of Aboriginal heritage.

The distribution of sites and the variety of site types indicates the following expectations for the land immediately around and within Lake Mokoan:

- Historic site types may occur around the boundaries of the lake, with material related to the areas pastoral and farming past;
- Aboriginal site types likely to be present include scarred trees, stone artefact scatters, mounds and burials. Rock wells and quarries are likely to occur within the hills surrounding the lake, but not associated with the lake itself;
- Stone artefact sites and mounds are most likely to have originally been located around the margins of the former swamps, particularly near creek inlets or rises, which may indicate more diverse micro-environments;
- Cultural scarring is likely to occur on mature trees, particularly on Red Gum and Box, throughout the study area; and
- Burials are quite likely to occur within the dune sands of the lunette and the dune at the western end of Lake Mokoan.

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## **1.7 Current Socio-Economic Situation**

Lake Mokoan augments the supply of water to private diverters for irrigated agriculture and for stock and domestic purposes in the Broken River, the Broken Creek and the lower Goulburn River. It also augments the supply available for other diversions that influence economic activity, such as, town water supplies, golf clubs and other recreation reserves. There are diversions directly from the Lake for irrigated agriculture, and stock and domestic purposes. As well as the direct output of agricultural products, economic activity is generated by the supply of farming inputs and the handling, transport and processing of those products.

Economic value and economic activity arise from the supply of recreational and tourism opportunities that the Lake produces. Currently, recreation on the Lake centres on: fishing, duck hunting, yachting, water skiing, wind surfing and jet skiing, and passive recreation, such as picnicking.

Economic activity also results from the industries that provide services to recreationists. Examples include hotels, motels, service stations, supermarkets, cafes, and specialty shops, such as, those providing fishing tackle, bait and boating requisites. While the outputs of these activities carry prices, few suppliers have information about the sales that are due specifically to Lake Mokoan. In addition, there is economic activity created by the expenditure of Goulburn-Murray Water to operate and maintain the lake. Most of this expenditure, such as, salaries and purchases of materials and equipment would be spent locally.

Indicators of the current economic contribution of Lake Mokoan to agricultural production around the lake and in the Broken basin, net economic value and spending on recreation in the region, and indicators of the costs associated with the current condition of the lake have been assessed.

### **1.7.1 Agriculture**

An indicative value of the gross annual value of agricultural production influenced by Lake Mokoan either directly or indirectly in the Broken basin is in the range from about \$26million to about \$35million. Wine grapes, stone fruit and dairying are the major contributors to this value.

### **1.7.2 Recreation**

It has been estimated that Lake Mokoan and its environs has about 10,650 visitors per year participating in water-based activities. The annual net economic value of this recreation might lie between \$238,000 and \$697,000 and that recreationists might spend between \$340,000 and \$696,000 per year when visiting the lake. An unknown but probably large proportion of this would be spent in the local region. Table 1-1 summarises the estimated annual expenditure by recreationists and the net annual economic value of recreation at Lake Mokoan.

**Table 1-1: Expenditure and economic value of recreation at Lake Mokoan**

Activity	Estimated number of person days	Estimated annual expenditure in region by recreationists at Lake Mokoan (\$)			Estimated annual net economic value to Lake Mokoan recreationists (\$)		
		Low	Mid-point	High	Low	Mid-point	High
Fishing	5,000	100,000	200,000	300,000	100,000	250,000	400,000
Duck hunting	2,600	174,000	186,000	198,000	110,000	135,000	160,000
Yachting	1,150	22,500	45,000	67,500	15,000	40,000	66,000
Water skiing	400	10,000	20,000	30,000	10,000	27,000	59,000
Day picnickers	1,500	33,000	68,000	100,000	3,000	7,500	12,000
<b>Totals (rounded)</b>	<b>10,650</b>	<b>340,000</b>	<b>519,000</b>	<b>696,000</b>	<b>238,000</b>	<b>460,000</b>	<b>697,000</b>

Some local businesses, particularly those supplying special goods and services to recreationists, such as fishing requisites and the Lake Mokoan Caravan Park, are likely to be more dependent on business arising from visitors to Lake Mokoan than those businesses that cater to a wider and more diverse clientele.

A group responsible for part of the above estimate of gross value of irrigated agriculture is wine tourists. It is estimated that about 22,500 such visitors spend about \$750,000 at the Lake Mokoan wineries.

**1.7.3 Other Issues**

The significant costs arising from the present state of the quality of Lake Mokoan are up to \$63,000 per year for water treatment in Shepparton due to turbidity, and an average cost of \$290,000 per year (range: \$150,000 to \$420,000 per year) arising from blooms of toxic blue-green algae.

The lake has only a minor effect on flood mitigation on the Broken River in Benalla but is an important source of water for fire fighting. The market for residential real estate appears stagnant awaiting resolution of the lake’s future.

**1.8 Consultation Process**

Over the months of August and September, 2002, there were some 20 consultation meetings involving more than 300 people. There were regular media releases informing the community on progress of the study and notifying them of opportunities to find out information and have input to the process.

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Most people involved in the consultation meetings expressed a desire to keep the lake in some form or another – preferably as it is now. Some of these desires stem from a difference of opinion in relation to the Government’s aims for this study and some from a concern or uncertainty of the future. During discussions community members came up with numerous suggestions to help keep or maintain the lake.

### 1.8.1 Water Savings Study

The SKM options were evaluated to determine the water saving, the storability of the saving and impact on system reliability and assessed for environmental and socio-economic effects. The options assessed by SKM are summarised in Volume 1 of the Final Report.

As part of the current study, community reaction was sought on the options as put forward by SKM with a view to incorporate these comments in the refining process where applicable.

There was vigorous discussion about each of the options proposed by SKM. This discussion led to proposals for refining those options. At most of the meetings people were negative about the options that had been put forward. This negativity was partly due to each of the following:

- the lack of information on each option;
- a back lash in relation to any loss of existing conditions; and
- lack of acceptance of the Government’s aim of water savings and the need to improve the environmental health and operating costs of the lake.

In most of the consultation meetings it took considerable debate before people acknowledged the Government’s aims. When those aims were acknowledged people began suggesting alternatives to the SKM options. They did this by describing what features were important to them and that they wished to see considered in any options that were investigated. Refinement of SKM options followed and a selection of these were evaluated by this study.

## 2.1 Option Refinement

### 2.1.1 Process

Each of the SKM options for partitioning the lake (see Volume 1) was revised to a wider set of options composed of different physical configurations and different full supply levels. Input from the community consultation process was considered in this process. A refined option(s) was chosen from each set according to a number of criteria that included estimated water savings, estimated costs per ML saved, including the costs of offsets, and by scoring on a judgemental scale the likely environmental and socio-economic effects relative to the relevant option proposed by SKM.

### 2.1.2 Community input into the refinement process

The Reference Committee discussed and considered all of the consultation input (as is posted on the website). This information was made available in full to the Consultants and in this process the Reference Committee emphasised:

- the need to determine short and long term environmental and water quality impacts of each option;
- that if there were to be a reduction in the area of the lake there is a need to determine the costs of constructing and maintaining a wetland area and to detail the benefits of such a wetland; and
- to explore the potential for agroforestry on any reclaimed area if the lake were partially drained.

Several community groups and the Reference Committee suggested that a revised partition option be considered. The suggestion was for a partition north from the spit and keeping the lake as deep as possible. People have suggested that such an option would result in deeper areas in some parts of the lake, thereby reducing turbidity, encourage fish habitat and reduce evaporation. It was believed that such an option should maintain reliability of supply and improve water quality.

During the course of the consultations the Save Lake Mokoan Committee (SLMC) submitted a proposal for a revised way of operating the existing lake that would entail increasing water levels and operating to revised standards. The details of this proposal are at the website [www.lakemokoan.com](http://www.lakemokoan.com) in the document 'Lake Mokoan Study Summary of Consultation Meetings' and in Appendix A of Volume 2.

### 2.1.3 The partitioning options for refinement

Three forms of partitioning were considered.

- A *contour bank* (referred to as alternative A) that would extend from the existing dam embankment at about RD 2,000m, east to the spit and would remove the gradually sloping area in the south-west corner of the lake.

- A *spit bank* (referred to as alternative B) following the line of the ridge separating Winton Swamp from Green Swamp. This bank would cut the lake in half from south to north removing the gradually sloping area at the eastern end of the lake and allow the re-establishment of the original wetlands in that area.
- A *combination bank* (referred to as alternative C) incorporating both the Contour and Spit Banks that would remove the gradually sloping areas in the south west part of the lake and at the eastern end of the lake.
- A *no bank* alternative (referred to as alternative D) that involves no extra banks but merely drops the level of the lake.

Table 2-1 shows the detail of the set of refined partitioning alternatives, namely, A,B, and C. The same partitioning alternatives were chosen for both Option 2 (permanent storage – current operation) and Option 3 (annual storage).

**Table 2-1: Partition Alternatives**

<b>Bank</b>	<b>Alternatives within the Partitioning Options</b>	<b>FSL</b>	<b>Capacity GL</b>	<b>Area Ha</b>	<b>Cost<sup>1</sup> \$million</b>
Contour	A1	166.9	320 (86%)	6,300 (78%)	76
	A2	164.5	184 (50%)	5,600 (69%)	47
	A3	163.0	107 (29%)	4,900 (61%)	32
Spit	B1	166.9	208 (56%)	4,400 (55%)	85
	B2	166.0	169 (46%)	4,100 (51%)	56
	B3	164.0	97 (26%)	3,000 (37%)	35
Combination	C1	166.9	164 (44%)	2,600 (32%)	120
	C2	165.0	114 (31%)	2,510 (31%)	81
	C3	164.0	89 (24%)	2,470 (31%)	65
No Bank	D1	164.5	198 (54%)	6,450 (80%)	9
	D2	163.0	108 (29%)	5,160 (64%)	4

<sup>1</sup> Costs are based on concept design only and therefore include a 40% contingency allowance  
Values in brackets are the percentage of current maximum storage capacity and area

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### **2.1.4 Options and offsets**

Reducing the storage capacity of Lake Mokoan may reduce the reliability of the Broken River system. In November 2002, the (then) Minister for Environment and Conservation guaranteed that there would be no adverse impact on the security of irrigators' existing water. This was confirmed by the Minister for Water in a letter to the Victorian Farmers Federation dated 18 March 2003. Therefore a number of alternatives that have been examined would reduce or eliminate any reduction of reliability in the system.

The alternatives for lessening the reduction in reliability are reducing the demand on the system, providing more efficient storage within the system or diverting water from alternative sources. An 'offset' is defined as a physical work undertaken to reduce the additional short fall created by a water saving. The purchase of water entitlement has not been considered as an offset either alone or in combination with any of the above offsets.

The offsets considered in the refinement process were:

- piping of Casey's Weir and Major Creek Waterworks District (Tungamah) system;
- supply Lake Mokoan diverters from Ovens or King Rivers;
- link Lake Eildon to Lake Nillahcootie;
- harvesting spills from Lake William Hovell in Lake Nillahcootie; and
- raising Lake Nillahcootie.

### **2.1.5 Options chosen for the Interim Report**

Using the process described in Section 2.1.1, the Steering Committee chose the following options for subsequent detailed analysis.

- 1** Reversion to Winton Swamp and associated wetlands.
- 2B3** Spit bank, 97GL capacity, current operation. High water savings (indicative estimate about 30GL), low cost per ML saved (indicative estimate about \$1,200/ML), relatively low environmental and socio-economic score but an improvement on the original SKM option.
- 3B3** Spit bank, 97GL capacity, annual storage operation. High water savings (indicative estimate about 34GL), low cost per ML saved (indicative estimate about \$1,000/ML), relatively low environmental and socio-economic score but a small improvement on original option. Same configuration as 2B3.
- 3C2** Spit and contour banks, 114GL capacity, annual storage operation. Similar water savings to 3B3, relatively low cost per ML saved (indicative estimate about \$2,100), higher environmental and socio-economic score than 3B3, slightly greater stored volume for slightly less area of storage than 3B3.
- 4** The proposal for a change in operating rules as put forward by the Save Lake Mokoan Committee.

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### **2.1.6 Community consultation on the Interim Report**

The Interim Report was completed and released to the public for comment on March 14, 2003. A copy of the report available at the Benalla Rural City Offices, the Benalla Library and DPI Offices in Benalla, the G-M Water office in Tatura, the MDBC in Canberra, and the GBCMA offices in Shepparton and Benalla. The Interim Report contained a proforma encouraging feedback and the community was provided with a six week period in which to respond to the Report. Reference Committee members were encouraged to interact with their constituents on the Interim Report and submit written comments.

Following public discussion and submissions from stakeholders on the Interim Report the Steering Committee revised the set of options to be subject to detailed analysis. The chosen options that were subjected to detailed analysis were:

- |                   |   |
|-------------------|---|
| <b>Option 1</b>   | <b>Return to Winton Swamp.</b>  |
| <b>Option 2B1</b> | <b>Spit bank, Permanent Storage, Deep, EL 166.9, capacity = 209GL (56 per cent of current), area = 4,400ha (55 per cent of current), operate as at present.</b>   |
| <b>Option 2B3</b> | <b>Spit bank, Permanent Storage, Shallow, EL 164, capacity = 97GL (26 per cent of current), area = 3,000ha (37 per cent of current), operate as at present.</b>   |
| <b>Option 3B1</b> | <b>Spit bank, Annual Storage, Deep, EL 166.9, capacity = 209GL (56 per cent of current), area = 4,400ha (55 per cent of current), operate as an annual storage but with a draw down limited to 100GL, that is, about 50 per cent of capacity.</b> |
| <b>Option 3B3</b> | <b>Spit bank, Annual Storage, Shallow, EL 164, capacity = 97GL (26 per cent of current), area = 3,000ha (37 per cent of current), operate as annual storage.</b>  |
| <b>Option 4</b>   | <b>Revised Operating Rules for Lake Mokoan, the Save Lake Mokoan Committee's proposal for changes to the operating rules.</b>   |

### **2.1.7 Analytical issues relevant to all options**

There are a number issues and assumptions that were common to the detailed analysis of all options. The following are the principal common items.

*Construction of spit bank.* Draining the lake for bank construction and total loss of recreation for two years

*Supply issues (offsets).* Costing and tailoring the offsets to meet the estimated shortfalls of each option.

*Dam safety issues.* Based on the current assessed level of risk and G-MW's response to similar levels of risk at other dams, it would be appropriate to commence work to reduce the dam safety risks posed by Lake Mokoan within the next five years. Initial work would focus on upgrading the most vulnerable aspect of the embankment at the outlet culvert, while in the long term, in about 10 years subject to the risk profile for all its dams, G-MW would need to complete upgrading of the embankment. The estimated

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cost to upgrade the embankment at the outlet culvert is \$5million and the general upgrading of the embankment is estimated to cost \$15million. Where an option has a shorten wall that requires rehabilitation, costs have been pro-rated accordingly.

*Modelling issues.* The evaluation of the options has been undertaken using the best available tools for the simulation modelling of the system. The model uses historical data and the system operating rules to determine a range of outputs. The system modelling is a worst case scenario in that it assumes that the changes to the configuration of Lake Mokoan will not reduce the closure of the storage for water supply due to the blue-green algae blooms. The modelling for the evaluation of the management options for Lake Mokoan has been undertaken using historical water usage in the Broken River system, which generally has been less than full licence volume due to the number ‘sleeper’ licences. To assess the impact of full licence uptake, the existing situation and each of the options with the offset required to satisfy current demand were also modelled.

*Water savings storability.* Decommissioning or altering the configuration of Lake Mokoan will result in water savings through a reduction in the volume of water lost through evaporation. This water will flow down the Broken, Goulburn and Murray Rivers as unregulated flow, predominantly in the winter/spring period. The ability to capture this water for future use is the water savings storability. Various opportunities for savings storability are considered.

*Environmental issues* and assumptions related the methods of analysis, the ecological theory for analysing shallow lakes, the habitats created by each option, the issue of wetland buffer zones, the attractiveness of the options to water birds, the conservation values of restored wetlands and the likely downstream effects of each option.

*Socio-economic issues*, including the absence of an effect of the options on irrigated agriculture on the Broken system arising from the statements of the (then) Minister for Environment and Conservation (November 2002) and the Minister for Water (March 2003) that there would be no adverse impact on the security of irrigators’ existing water entitlements. Indicative values of water savings as environmental flows, a set of assumptions concerning implications for recreation and local businesses, and assumptions concerning water treatment at Shepparton, the costs of algal blooms, and implications for flooding.

A benefit-cost analysis is undertaken for each option relative to continuing current conditions. Two real (inflation free) rates of discount are used to convert future sums of money to equivalent present values so that benefits and costs can be compared at a common point in time. Rates of 4 per cent and 8 per cent are used to demonstrate the sensitivity of the results to this parameter. As far as possible unpriced benefits and costs are valued in dollars so that they are compared using a common denominator. Items that cannot be valued in dollars are described. For the Options that utilise the pipelining of the Tungamah system as the offset, namely, Options 2B1 and 2B3, an estimate of the benefits of pipelining the system are included in the analysis as well as the costs. In other words, it is assumed that the pipelining is part of the Lake Mokoan project.

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## **2.2 Potential Uses of Reclaimed Land**

Approximately 5,700 ha of farmland were inundated by the formation of Lake Mokoan. Draining of all or part of the lake would liberate considerable amounts of land for commercial or other uses. Reclaimed land for commercial use is net of remaining land still inundated, re-established wetlands and wetland buffer zones for each option. Soil condition on the drained bed of Lake Mokoan is expected to have degraded due to over 30 years of inundation, however the extent of this degradation is unknown.

A range of possible uses for the reclaimed land were considered. Because of the uncertainty about the nature of the land and the vast array of possible uses, the uses considered should be interpreted as stylised examples of what might be possible. The alternatives for reclaimed land considered by this analysis included a range of agricultural and plantation forestry ventures. Agricultural enterprises include those that were known to exist on the land prior to the construction of Lake Mokoan (beef cattle, prime lambs, dryland cereal crops) and plantation forestry ventures include Ironbark, Sugar, Blue and Spotted gum and Pine plantation regimes.

The indicative results suggested that agricultural land use regimes, at a 4 per cent discount rate, would be potentially profitable but marginal or unprofitable at an 8 per cent discount rate. Importantly, the land in the north-east portion of the lake is unlikely to support profitable agricultural enterprises. The results for the commercial forestry options indicate that all of these options are unlikely to provide a positive economic return (applying a discount rate of 8 per cent). At a 4 per cent discount rate, Ironbark and/or Sugar gum firewood plantations might be the only species that would provide a positive return, considerably greater than agricultural land use for options 2B3 and 3B3, but lower under the remaining options.

Revegetation of the reclaimed land for site regeneration, salinity mitigation, biodiversity and carbon sequestration are also valid options for consideration – these may be combined with the commercial forestry options if appropriate. Revegetation is an investment, imposing today the costs of establishment and forgoing agricultural production, for the benefits of reduced salinity in the future. Furthermore, while the costs of revegetation are reasonably certain, the benefits of reduced stream and land salinity and other unpriced benefits such as passive recreation are not as well quantified.

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## **2.3 Option 1 Return to Winton Swamp**

### **2.3.1 Description and costs**

The decommissioning of Lake Mokoan to re-establish Winton Swamp involves draining the lake, fixing the outlet gates open, removing Hollands and Broken River Weirs, backfilling and revegetating the inlet and outlet channels, removing the channel structures, reinstating existing water supplies, rehabilitating the drained lake area and removing redundant community assets. It would also save the expenditure required for the embankment rehabilitation. The re-establishment of the Winton Swamp as a wetland will require ponding water to a depth of one metre, which equates to a volume of 20GL. The option requires supplementary supply from Lake Eildon to Lake Nillahcootie to maintain the current reliability of supply. The estimated cost of decommissioning Lake Mokoan, installing offsets and re-establishing Winton Swamp is estimated to be about \$67million with ongoing annual costs of \$340,000 to \$355,000.

The decommissioning of the lake will produce average annual water savings of 38GL with an average annual shortfall in the Goulburn system of 7GL, which has a negligible impact on that system.

Without the lake, any new development in the Warby Ranges would require supply from the Broken system to be taken from the Broken River. This would increase the present value of costs for Stage 1 by \$36million for the peak supply rate and \$19million for the average supply rate, and Stage 2 by \$27million and \$16million respectively.

### **2.3.2 Environmental issues**

Draining Lake Mokoan and restoring the original Winton Swamp will recreate 8 former wetlands. Two of the wetlands are large - the Winton Central and Western Wetlands (treated as one wetland) and Green Swamp. The six smaller wetlands to the south and east of Green Swamp are Ashmeads, Black, Humphries, Lindsays, Saddlers and Taminick Swamps.

The area of restored wetlands will be approximately 2,208ha. Buffer strips of 200m width around the wetlands will cover another 913ha. The remaining area that can be restored to commercial use is 4,779ha. A significant amount of this area will require soil restoration.

No consumptive uses of water are planned from any of the wetlands restored under Option 1. The shallow depth will allow aquatic vegetation to proliferate which is expected to produce low water turbidity.

Seedbank studies have shown that a healthy seedbank exists from the Lake Mokoan FSL down to 46 per cent of FSL (the limit of study to date). In this region, the land should self-sow when Lake Mokoan is drained. Below 46 per cent and down to the level of the wetlands (around 10 per cent of FSL) the land may need to be sown with pasture to stabilise the soil and prevent erosion.

Buffer zones around wetlands will require fencing from adjacent agricultural land and revegetation with local provenance eucalypts by direct seeding augmented with tubestock in some areas.

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Smaller wetlands are expected to revegetate naturally but may require donor soil containing wetland plant seeds (i.e. seedbank material) from nearby existing wetlands (e.g. the Duck Pond on the northwest perimeter of Lake Mokoan). Indicative costings are provided for revegetating 100ha of wetland perimeter through the addition of donor soil.

The recreational fishery that currently exists in Lake Mokoan will cease to exist, however waterbird communities and duck hunting activities are expected to benefit from the increased area of shallow vegetated water and greater diversity of habitats.

A preliminary conservation assessment indicated that the restored wetlands (incorporating all the wetlands listed above) could reasonably be expected to meet two of the criteria for nationally important wetlands and possibly one of the criteria (based on waterbird abundance) for wetlands of international significance. However a proper assessment against all such criteria could only undertaken once the wetlands were restored.

### 2.3.3 Heritage issues

The principal works required in the reversion to Winton Swamp would include the removal of weirs and channels, the modification and rehabilitation of the inlet and outlet channels and environmental works. The potential relative extent of the impact of these works would include:

- minor disturbance of local sediments at point of works (but areas have already suffered disturbance through construction of infrastructure);
- initiation of erosion by bank destabilisation;
- immediate effects of exposure/drying on waterlogged archaeological deposits (eg cracking of mound clays, vertical movement of artefacts); and
- rotting of exposed scarred trees.

Long-term impacts could include the stabilisation of the sedimentary matrix and continued preservation of surviving archaeological sites.

### 2.3.4 Economic benefits and costs

Displayed in Table 2-2 are indicative estimates of the benefits and costs of Option 1 relative to the current situation.

**Table 2-2: Benefits and costs of Option 1**

<b>Benefits resulting directly from Option 1</b>		
<b>Item</b>	<b>PV at 4% (\$m)</b>	<b>PV at 8% (\$m)</b>
Water savings (@\$70/ML/year)	57.1	32.5
Commercial land use (based on agriculture)	1.8	0.3
Savings in cost of water treatment in Shepparton	1.3	0.7
Savings in costs of algal blooms	6.0	3.3
<b>Costs associated with current operation not incurred under Option 1</b>		
Current management and operation costs avoided	12.5	7.1
<b>Total quantified benefits</b>	<b>78.6</b>	<b>43.9</b>
<b>Benefits of current operation given up under Option 1</b>		
Loss of net economic value of recreation activities	4.3	2.9
<b>Extra costs associated with Option 1</b>		
Capital costs of works	13.5	13.1
Annual costs of works	2.8	1.5
Capital costs of offsets	50.0	48.1
Annual costs of offsets	3.9	2.1
Drainage costs	0	0
Bank rehabilitation costs	0	0
Wetland establishment costs	0.2	0.2
Buffer establishment costs	0.7	0.6
Wetland and buffer maintenance costs	0.4	0.3
<b>Total quantified costs</b>	<b>75.7</b>	<b>68.8</b>
<b>Net Present value</b>	<b>2.9</b>	<b>-24.9</b>

***Unquantified benefits***

The recreation use benefits (such as, walking, and bird watching), the indirect use benefits (such as nutrient assimilation), and any non-use benefits of a large area of re-instated wetland. If the value of all other benefits (including the unpriced value of a re-instated wetland) were higher than assumed here they would increase the margin of ‘profit’ of the option at 4 per cent. At 8 per cent, however, all benefits other

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than water savings would need to have combined present value of \$24.9million for the option to breakeven. This is equivalent to an annual value of \$2.0million per year for 50 years.

### ***Unquantified costs***

The potential for a once-off decline in land values in the vicinity of the lake estimated by Linqage International (2001) to lie between \$1million and \$5million).

### ***Local effects***

Potential loss of annual expenditure by recreationists in the range from \$32,000 to \$200,000 – mid-point \$116,000.

The Lake Mokoan Caravan Park would be unlikely to be a viable business under this option. The effects on other accommodation facilities have not been estimated but it is believed that they would be small.

### ***Selected sensitivity analyses***

With the quantity of water savings given, the results suggest that the largest contributors to the net present value of the option are the rate of discount, the costs of works, the costs of offsets and the value of water savings. The costs are known with a greater degree of certainty than the value of water savings and the rate of discount. Therefore, the sensitivity of the results to these variables is investigated.

#### *Discount rate*

The results are sensitive to the rate of discount. This is because of the large costs that are incurred at the beginning of the project while the benefits are long lived. The higher the discount rate the smaller the present value of benefits but there is little change in the present value of costs.

#### *Value of water savings*

The above results were generated for a value of \$70/ML/year – corresponding to a capitalised value at 4 per cent (8 per cent) of \$1,500 (\$850). The breakeven values of water savings, that is, the value at which the present value of benefits would equal the present value of costs (net present value equals zero) would \$66/ML/year at 4 per cent and \$124/ML/year at 8 per cent. These correspond to capitalised values (over 50 years) of \$1,428/ML at 4 per cent and \$1,512/ML at 8 per cent.

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## **2.4 Option 2B1. Spit Bank, Permanent Storage, Deep**

### **2.4.1 Description and costs**

The ‘Spit Bank, Permanent Storage, Deep’ proposal for Lake Mokoan involves maintaining the current full supply level and operating rules and reducing the lake evaporative capacity by the construction of a partitioning bank across the spit. One location for a bank that will remove the shallow eastern end of the lake from the storage is the natural ridge that separated Winton Swamp from Green Swamp and forms a ‘spit’ on the southern shoreline. Making use of the ridge and minimises the height and length of the bank and retains the deepest part of the lake. The partitioned lake will have a capacity and surface area of 208GL and 4,410ha respectively.

Whilst the lake is principally an off-stream storage and filled by a channel diverting flow from the Broken River and Hollands Creek, it has a small local catchment. Most of this catchment is upstream of the proposed partitioning bank. The existing lake does not have a spillway due to the embankment being designed with sufficient height to store the local catchment area probable maximum flood (PMF) volume. The partitioning of the lake will require the provision of drainage works to pass runoff from local catchment to maintain the integrity of the storage. The proposal is to construct a drainage pipeline that will pass below the bed of the storage around the edge of the original Winton Swamp. An alternative, but uncosted, approach would be to pump the runoff into the re-configured lake.

The option will also require the rehabilitation of the area removed from the storage, the provision of water supply to the Lake Mokoan diverters at the eastern end of the lake and the full rehabilitation of the existing embankment.

This option requires the replacement of the Tungamah domestic and stock channel system with a pipeline system to maintain the current reliability of supply. The estimated cost of partitioning Lake Mokoan at its current FSL and operating it to the current rules is about \$98.2million with ongoing annual costs of \$718,000 to \$728,000.

The ‘Spit Bank, Permanent Storage, Deep’ proposal will produce average annual water savings of 22GL. Partitioning Lake Mokoan at the spit will increase the present value of cost of supply from Lake Mokoan for new development in the Warby Ranges for Stage 1 at the peak rate by \$10million and at the average rate by \$6million. The present value cost for supply to Stage 2 will increase by \$2.7 and \$1.4million respectively.

### **2.4.2 Environmental issues**

Under this option an earth bank would be constructed from the northern-most part of the spit to the existing northern shoreline at a height of 166.9m AHD. Some earthworks would also be necessary on top of the spit to maintain this water level. Seven wetlands (all but the former Central and Western Wetlands of Winton Swamp) would be recreated. The 7 wetlands are Green, Ashmeads, Black, Humphries, Lindsays, Saddlers and Taminick Swamps. The re-configured Lake Mokoan would have a maximum

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depth of 7 to 8m at FSL and a likely minimum depth of 2 to 3m during periods of major draw down. Drainage of the catchment upstream of Lake Mokoan will require construction of 7.5km of twin 1.8m diameter pipes running upstream of the Spit bank to downstream of the existing Lake Mokoan embankment. Lake water levels would be managed in a similar fashion to the existing lake.

The establishment of a new eastern perimeter to the lake at the Spit Bank will greatly reduce the area of the lakebed subject to high wave action which resuspends sediment and contributes to lake turbidity. Decreased turbidities are expected to enhance lake revegetation.

The area of restored wetlands will be approximately 469ha. Buffer strips of 200m width around the wetlands will cover another 440ha. The remaining area that can be restored to commercial use is 2,590ha.

Revegetation and soil restoration issues are similar to those described for Option 1 and are described in the report.

The recreational fishery that currently exists in Lake Mokoan will cease to exist when the lake is drawn down for construction, However, subsequent refilling and restocking should allow a new fishery to be established.

The smaller size of the re-configured lake is expected to lead to reduced populations of common waterbird species on Lake Mokoan, although the resulting populations will remain significant due to the still relatively large size of the lake. The restored wetlands to the east of the Lake will also offer a greater variety of preferred habitat for many waterbirds including hunted duck species.

The assessment of the possible conservation status of the lake and wetlands yielded the same result as described for Option 1.

### **2.4.3 Heritage issues**

The main works would be the construction of the spit bank, drainage works, and environmental works. The expected effects would include those indicated for Option 1, plus significant damage to the lunette, resulting in destruction of unquantified but predictably significant archaeological deposits – possibly burials. Eventually archaeological deposits would stabilise.

### **2.4.4 Economic benefits and costs**

Displayed in Table 2-3 are the estimated benefits and costs of Option 2B1 relative to the current situation.

**Table 2-3: Benefits and costs of Option 2B1**

<b>Benefits resulting directly from Option 2B1</b>		
<b>Item</b>	<b>PV at 4% (\$m)</b>	<b>PV at 8% (\$m)</b>
Water savings (@\$70/ML/year)	33.1	18.8
Estimated remaining benefits of Tungamah pipeline	10.1	6.7
Commercial land use (based on agriculture)	0.2	-0.08
Savings in cost of water treatment in Shepparton	1.0	0.5
Savings in costs of algal blooms	6.0	3.3
<b>Costs associated with current operation not incurred under Option 2B1</b>		
Current management and operation costs avoided	11.3	6.4
<b>Total quantified benefits</b>	<b>57.7</b>	<b>33.2</b>
<b>Benefits of current operation given up under Option 2B1</b>		
Loss of net economic value of recreation activities	2.6	2.1
<b>Extra costs associated with Option 2B1</b>		
Capital costs of works	40.4	38.9
Annual costs of works	12.6	7.0
Capital costs of offsets	11.7	11.3
Annual costs of offsets	1.6	0.9
Drainage costs	22.4	21.4
Bank rehabilitation costs	14.2	10.4
Wetland establishment costs	0.1	0.1
Buffer establishment costs	0.3	0.3
Wetland and buffer maintenance costs	0.3	0.2
<b>Total quantified costs</b>	<b>106.3</b>	<b>92.6</b>
<b>Net Present value</b>	<b>-49.1</b>	<b>-59.4</b>

***Unquantified benefits***

The recreation use benefits (such as, walking, and bird watching), the indirect use benefits (such as nutrient assimilation), and any non-use benefits of a large area of re-instated wetland. If the value of all benefits other than water savings (including the unpriced value of a re-instated wetland) were higher than assumed here they would need to have combined present value of \$49.1million at 4 per cent or

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\$59.4million at 8 per cent for the option to breakeven. These present values are equivalent to an annual value at 4 per cent (8 per cent) of \$2.3million per year (\$4.9million) for 50 years.

### ***Unquantified costs***

The potential for a once-off change in land values in the vicinity of the lake.

### ***Local effects***

Potential gain of annual expenditure by recreationists in the range from \$37,000 to \$47,000 – mid-point \$42,000. Most of this would arise from spending by extra duck hunters.

No loss in visitation at neither the Lake Mokoan Caravan Park nor other accommodation facilities would be expected.

### ***Selected sensitivity analyses***

With the quantity of water savings given, the results suggest that the largest contributors to the net present value of the option are the rate of discount, the costs of works (including dam rehabilitation costs), the costs of offsets and the value of water savings. The costs are known with a greater degree of certainty than the value of water savings and the rate of discount. Therefore, the sensitivity of the results to these variables is investigated. At the request of the Study's Reference Committee, the effect of deleting dam rehabilitation costs os also investigated.

#### *Discount rate*

The results are sensitive to the rate of discount. This is because of the large costs that are incurred at the beginning of the project while the benefits are long lived. The higher the discount rate the smaller the present value of benefits but there is little change in the present value of costs.

#### *Value of water savings*

The above results were generated for a value of \$70/ML/year – corresponding to a capitalised value at 4 per cent (8 per cent) of \$1,500 (\$850). The breakeven values of water savings, that is, the value at which the present value of benefits would equal the present value of costs (net present value equals zero) would be about \$195/ML/year at 4 per cent and about \$315/ML/year at 8 per cent. These correspond to capitalised values (over 50 years) of \$4,190/ML at 4 per cent and \$3,853/ML at 8 per cent.

#### *Without dam rehabilitation costs*

If dam rehabilitation costs are removed, the net present value at 4 per cent (8 per cent) is minus \$35million (minus \$49million). The breakeven value of water savings at 4 per cent (8 per cent) falls to about \$165/ML/year (\$277/ML/year). These correspond to capitalised values over 50 years of \$3,552 (4 per cent) and \$3,388 (8 per cent).

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## **2.5 Option 2B3. Spit Bank, Permanent Storage, Shallow**

### **2.5.1 Description and costs**

The ‘Spit Bank, Permanent Storage, Shallow’ proposal for Lake Mokoan involves maintaining the current operating rules and reducing the lake evaporative capacity by the construction of a partitioning bank across the spit and lowering full supply level. The location of the partitioning bank is the same as for the Spit Bank, Permanent Storage, Deep Option. The partitioned lake with lowered FSL will have a capacity and surface area of 97GL and 3,080ha respectively.

The lower lake FSL will allow runoff from the local catchment upstream of the storage to be passed by a combination of low flow pipe and floodway around the southern side of the lake. The material excavated from the floodway will be used in the partitioning bank. The option will also require the rehabilitation of the area removed from the storage, the provision of water supply to the Lake Mokoan diverters at the eastern end of the lake and the partial rehabilitation of the existing embankment.

This option requires the replacement of the Tungamah domestic and stock channel system with a pipeline system to maintain the current reliability of supply. The estimated cost of partitioning Lake Mokoan at the lower FSL and operating it to the current rules is \$47.2million with ongoing annual costs of \$673,000 to \$683,000.

The ‘Spit Bank, Permanent Storage, Shallow’ proposal will produce average annual water savings of 31GL. The changes in cost for the Warby development will be the same as for Option 2B1.

### **2.5.2 Environmental issues**

Option 2B3 is similar to Option 2B1, the differences being in the height of the spit bank, which would be constructed at 164m AHD, the resultant maximum depth of the lake (around 4m at FSL) and instead of pipes to drain the upstream catchment, a bypass floodway would direct runoff around the southwest of the lake.

More of the lakebed will be subject to turbidity inducing wave action than Option 2B1 due to the shallower depth, however, a greater area of the lake is expected to have a suitable depth for aquatic vegetation which may help counter the effect of wave action on turbidity.

The area of restored wetlands and buffer strips will be the same as for Option 2B1. The remaining area that can be restored to commercial use is 3,990ha.

Revegetation and soil restoration issues are similar to those described for Option 1 and are described in the report.

Construction impacts are the same as described for Option 2B1. The re-established fishery in the new lake will be smaller than would be likely under Option 2B1 due to the smaller lake area (65 per cent of

Option 2B1) and the possibility that Fisheries Victoria would not stock the lake in years of low water levels (due to the reduced carrying capacity).

The effect on waterbird numbers is likely to be species specific with some species (including hunted species) actually benefiting from the increased area of aquatic vegetation that is expected to occur in the lake.

The assessment of the possible conservation status of the lake and wetlands yielded the same result as described for Option 1.

**2.5.3 Heritage issues**

The main works would be the construction of the spit bank, drainage works, and environmental works. The expected effects would include those indicated for Option 1, plus significant damage to the lunette, resulting in destruction of unquantified but predictably significant archaeological deposits – possibly burials. Eventually archaeological deposits would stabilise.

**2.5.4 Economic benefits and costs**

Displayed in Table 2-4 are the estimated benefits and costs of Option 2B3 relative to the current situation.

**Table 2-4: Benefits and costs for Option 2B3**

<b>Benefits resulting directly from Option 2B3</b>		
<b>Item</b>	<b>PV at 4% (\$m)</b>	<b>PV at 8% (\$m)</b>
Water savings (@\$70/ML/year)	46.6	26.5
Estimated remaining benefits of Tungamah pipeline	7.3	4.8
Commercial land use (based on agriculture)	0.05	-0.3
Savings in cost of water treatment in Shepparton	1.0	0.5
Savings in costs of algal blooms	6.0	3.3
<b>Costs associated with current operation not incurred under Option 2B3</b>		
Current management and operation costs avoided	11.3	6.4
<b>Total quantified benefits</b>	<b>67.8</b>	<b>38.7</b>

<b>Benefits resulting directly from Option 2B3</b>		
<b>Item</b>	<b>PV at 4% (\$m)</b>	<b>PV at 8% (\$m)</b>
<b>Benefits of current operation given up under Option 2B3</b>		
Loss of net economic value of recreation activities	3.2	2.4
<b>Extra costs associated with Option 2B3</b>		
Capital costs of works	21.1	20.4
Annual costs of works	11.8	6.5
Capital costs of offsets	11.7	11.3
Annual costs of offsets	1.6	0.9
Drainage costs	5.9	5.6
Bank rehabilitation costs	4.3	3.1
Wetland establishment costs	0.1	0.1
Buffer establishment costs	0.3	0.3
Wetland and buffer maintenance costs	0.3	0.2
<b>Total quantified costs</b>	<b>60.5</b>	<b>50.9</b>
<b>Net Present value</b>	<b>7.3</b>	<b>-12.2</b>

***Unquantified benefits***

The recreation use benefits (such as, walking, and bird watching), the indirect use benefits (such as nutrient assimilation), and any non-use benefits of a large area of re-instated wetland. . If the value of all other benefits (including the unpriced value of a re-instated wetland) were higher than assumed here they would increase the margin of ‘profit’ of the option at 4 per cent. At 8 per cent, however, all benefits other than water savings would need to have combined present value of \$12.2million for the option to breakeven. This present value is equivalent to an annual value at 8 per cent of about \$1million per year (\$1.8million) for 50 years.

***Unquantified costs***

The potential for a once-off change in land values in the vicinity of the lake.

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### **Local effects**

Potential change in local expenditure by recreationists in the range from a gain of about \$44,000 to a loss of about \$40,000 – midpoint almost no change from current conditions. Spending by extra duck hunters would be likely to compensate for reduced spending by anglers and yachtsmen.

The Lake Mokoan Caravan Park would be unlikely to be a viable business under this option.

### **Selected sensitivity analyses**

With the quantity of water savings given, the results suggest that the largest contributors to the net present value of the option are the rate of discount, the costs of works (including dam rehabilitation costs), the costs of offsets and the value of water savings. The costs are known with a greater degree of certainty than the value of water savings and the rate of discount. Therefore, the sensitivity of the results to these variables is investigated. At the request of the Study's Reference Committee, the effect of deleting dam rehabilitation costs was also investigated.

#### *Discount rate*

The results are sensitive to the rate of discount. This is because of the large costs that are incurred at the beginning of the project while the benefits are long lived. The higher the discount rate the smaller the present value of benefits but there is little change in the present value of costs.

#### *Value of water savings*

The above results were generated for a value of \$70/ML/year – corresponding to a capitalised value at 4 per cent (8 per cent) of \$1,500 (\$850). The breakeven values of water savings, that is, the value at which the present value of benefits would equal the present value of costs (net present value equals zero) would be \$60/ML/year at 4 per cent and \$114/ML/year at 8 per cent. These correspond to capitalised values (over 50 years) of \$1,290/ML at 4 per cent and \$1,389/ML at 8 per cent.

#### *Without dam rehabilitation costs*

If dam rehabilitation costs are removed, the net present value at 4 per cent (8 per cent) is plus \$11.6million (minus \$9.1million). The breakeven value of water savings at 4 per cent (8 per cent) falls to about \$50/ML/year (\$106/ML/year). These correspond to capitalised values over 50 years of \$1,080 (4 per cent) and \$1,296 (8 per cent).

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## **2.6 Option 3B1. Spit Bank, Annual Storage, Deep**

### **2.6.1 Description and costs**

The ‘Spit Bank, Annual Storage, Deep’ proposal for Lake Mokoan involves maintaining the current lake FSL and reducing the lake evaporative capacity by the construction of a partitioning bank across the spit and operating it as an annual storage. The size and location of the partitioning bank is the same as for the Spit Bank, Permanent Storage, Deep Option. Changes to the lake operation involve the drawing down the storage to a capacity of 100GL by the end of January each year. The partitioned lake will have a capacity and surface area of 208GL and 4,400ha respectively.

The works required to drain the area upstream of the partitioning bank are the same as for the Spit Bank, Permanent Storage, Deep Option.

No offsets are required, as there is no increase in shortfall, although the February allocations indicate that there is a reduction in the system reliability. The estimated cost of partitioning Lake Mokoan at its current FSL and operating it as an annual storage is about \$86million with ongoing annual costs of \$638,000 to \$648,000.

The ‘Spit Bank, Annual Storage, Deep’ proposal will produce average annual water savings of 25GL. There is negligible opportunity to store the water savings. Partitioning Lake Mokoan at the spit will increase the cost of supply for new development in the Warby Ranges by about 10 per cent for Stage 1 and 5 per cent for Stage 2.

### **2.6.2 Environmental issues**

Option 3B1 is similar to option 2B1 except that filling would occur over winter-spring followed by draw down to about 164m AHD (Option 3B1) by January. The summer minimum draw down leaves a residual volume of 100,000ML in the lake (about half the FSL volume) largely for recreational and environmental purposes. Maximum lake depth would be about 7m in winter and about 4 m in summer. In dry years, the lake may be drawn down to less than 100,000ML.

This option poses problems for water quality, as the large annual fluctuations in water level are likely to prove too harsh for most aquatic macrophytes. As a result there will be large areas of bare ground which could be subject to erosion and cause increased turbidities. The lack of macrophytes and possible high turbidities means that blue-green algae will be favoured and regular algal blooms may be expected.

The area of restored wetlands and buffer strips will be the same as for Option 2B1. The remaining area that can be restored to commercial will be the same as for Option 2B3.

Revegetation and soil restoration issues are similar to those described for Option 1 and are described in the report.

Construction impacts are the same as described for Option 2B1. The likely poorer water quality, lesser extent of aquatic vegetation, and greater annual variability of water levels will provide a poorer fish habitat than Option 2B1. Stocking levels will be set by the annual average low water level and therefore angler catches will be reduced in winter when the lake is full and the fish are dispersed over a wider area.

Within Lake Mokoan, the reduced extent of aquatic vegetation is expected to have minor to moderate negative effect on waterbird habitat including hunted species. As discussed under Option 2B1, the restored wetlands to the east should provide good waterbird habitat.

The assessment of the possible conservation status of the lake and wetlands indicated that the combined lake and wetland complex would not be likely to meet the same requirements for nationally or internationally significant wetlands as would Options 1, 2B1 and 2B3. As noted for Option 1, a proper assessment against all such criteria can only undertaken once the wetlands are restored.

**2.6.3 Heritage issues**

The works would be similar to Option 2B1, and would have effects similar to that options, plus there would be some effects of cycles of wetting and drying which would further destabilise archaeological deposits.

**2.6.4 Economic benefits and costs**

Displayed in Table 2-5 are the estimated benefits and costs of Option 3B1 relative to the current situation.

**Table 2-5: Benefits and costs for Option 3B1**

<b>Benefits resulting directly from Option 3B1</b>		
<b>Item</b>	<b>PV at 4% (\$m)</b>	<b>PV at 8% (\$m)</b>
Water savings (@\$70/ML/year)	37.6	21.4
Commercial land use (based on agriculture)	0.2	-0.08
Savings in cost of water treatment in Shepparton	0	0
Savings in costs of algal blooms	0	0
<b>Costs associated with current operation not incurred under Option 3B1</b>		
Current management and operation costs avoided	11.3	6.4
<b>Total quantified benefits</b>	<b>49.1</b>	<b>27.8</b>

<b>Benefits resulting directly from Option 3B1</b>		
<b>Item</b>	<b>PV at 4% (\$m)</b>	<b>PV at 8% (\$m)</b>
<b>Benefits of current operation given up under Option 3B1</b>		
Loss of net economic value of recreation activities	3.5	2.6
<b>Extra costs associated with Option 3B1</b>		
Capital costs of works	40.4	38.9
Annual costs of works	12.6	7.0
Capital costs of offsets	0	0
Annual costs of offsets	0	0
Drainage costs	21.4	20.5
Bank rehabilitation costs	14.2	10.4
Wetland establishment costs	0.1	0.1
Buffer establishment costs	0.3	0.3
Wetland and buffer maintenance costs	0.3	0.2
<b>Total quantified costs</b>	<b>93.9</b>	<b>80.8</b>
<b>Net Present value</b>	<b>-44.8</b>	<b>-53.0</b>

***Unquantified benefits***

The recreation use benefits (such as, walking, and bird watching), the indirect use benefits (such as nutrient assimilation), and any non-use benefits of a large area of re-instated wetland. If the value of all benefits other than water savings (including the unpriced value of a re-instated wetland) were higher than assumed here they would need to have combined present value of \$44.8million at 4 per cent or \$53.0million at 8 per cent for the option to breakeven. These present values are equivalent to an annual value at 4 per cent (8 per cent) of \$2.1million per year (\$4.3million) for 50 years.

***Unquantified costs***

The potential for a once-off change in land values in the vicinity of the lake.

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### **Local effects**

Potential for a change in local expenditure by recreationists in the range from a gain of about \$9,000 to a loss of about \$60,000 – midpoint loss of about \$26,000. Suppliers of fishing requisites might suffer a 20 per cent reduction in sales.

The Lake Mokoan Caravan Park would be unlikely to be a viable business. The effects on other accommodation facilities have not been estimated but it is believed that they would be small.

### **Selected sensitivity analyses**

With the quantity of water savings given, the results suggest that the largest contributors to the net present value of the option are the rate of discount, the costs of works (including dam rehabilitation costs), the costs of offsets and the value of water savings. The costs are known with a greater degree of certainty than the value of water savings and the rate of discount. Therefore, the sensitivity of the results to these variables is investigated. At the request of the Study's Reference Committee, the effect of deleting dam rehabilitation costs was also investigated.

#### *Discount rate*

The results are sensitive to the rate of discount. This is because of the large costs that are incurred at the beginning of the project while the benefits are long lived. The higher the discount rate the smaller the present value of benefits but there is little change in the present value of costs.

#### *Value of water savings*

The above results were generated for a value of \$70/ML/year – corresponding to a capitalised value at 4 per cent (8 per cent) of \$1,500 (\$850). The breakeven values of water savings, that is, the value at which the present value of benefits would equal the present value of costs (net present value equals zero) would be \$153/ML/year at 4 per cent and \$243/ML/year at 8 per cent. These correspond to capitalised values (over 50 years) of \$3,297/ML at 4 per cent and \$2,980/ML at 8 per cent.

#### *Without dam rehabilitation costs*

If dam rehabilitation costs are removed, the net present value at 4 per cent (8 per cent) is minus \$30.6million (minus \$42.7million). The breakeven value of water savings at 4 per cent (8 per cent) decreases to \$127/ML/year (\$209/ML/year). These correspond to capitalised values over 50 years of \$2,727 (4 per cent) and \$2,556 (8 per cent).

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## **2.7 Option 3B3. Spit Bank, Annual Storage, Shallow**

### **2.7.1 Description and costs**

The ‘Spit Bank, Annual Storage, Shallow’ proposal for Lake Mokoan involves reducing the lake evaporative capacity by the construction of a partitioning bank across the spit, lowering the lake FSL and operating it as an annual storage. The size and location of the partitioning bank is the same as for the Spit Bank, Permanent Storage, Shallow Option. Changes to the lake operation involve the drawing down the storage to a capacity of 15GL by the end of January each year. The partitioned lake will have a capacity and surface area of 97GL and 3,080ha respectively.

The works required to drain the area upstream of the partitioning bank are the same as for the Spit Bank, Permanent Storage, Shallow Option.

The option requires supplementary supply from Lake Eildon to Lake Nillahcootie to maintain the current reliability of supply. The estimated cost of reducing the capacity of Lake Mokoan and operating it as an annual storage is about \$85million with ongoing annual costs of \$719,000 to \$729,000.

The ‘Spit Bank, Annual Storage, Deep’ proposal will produce average annual water savings of 35GL with an average annual shortfall in the Goulburn system of 6GL, which has a negligible impact on that system. Storability of the water savings is limited to the substitution of about 4GL to meet the Lindsay River diversion dilution flow. Partitioning Lake Mokoan at the spit will increase the cost of supply for new development in the Warby Ranges by about 10 per cent for Stage 1 and 5 per cent for Stage 2.

### **2.7.2 Environmental issues**

Option 3B3 is similar to option 3B1 except that the height of the Spit Bank would be 164m AHD and the summer draw down would be approximately to 160.5m AHD. Maximum lake depth would be about 4m in winter and about 1m in summer (or similar to the maximum depth of the former Winton Swamp). As for option 2B1 instead of pipes to drain the upstream catchment (as proposed for 2B1 and 3B1), a bypass floodway would direct runoff around the southwest of the lake.

As indicated for Option 3B1, this option poses problems for water quality, as the large annual fluctuations in water level are likely to prove too harsh for most aquatic macrophytes. There will be larger areas of bare ground exposed during draw down than for Option 3B1. More of the lake bed will be subject to turbidity inducing wave action and the lack of macrophytes and likely high turbidities means that blue-green algae will be favoured and regular algal blooms can be expected.

The area of restored wetlands, wetland buffer strips and the area that can be restored to commercial use are identical to Option 2B3.

Revegetation and soil restoration issues are similar to those described for Option 1 and are described in the report.

Issues associated with operating the lake as an annual storage have already been described under Option 3B1 above. However, with an average depth of 1m in summer, the lake would offer poor fish habitat and Fisheries Victoria advise that they would not stock the lake under these circumstances. With the absence of other species including large native predatory fish like Golden Perch and Murray Cod, and the harsh environmental conditions, Carp may be favoured.

Considerations for waterbirds including hunted species for this option are similar to those of Option 3B1 although the habitat for waterbird species in the lake is expected to be poorer.

The assessment of the possible conservation status of the lake and wetlands yielded the same result as described for Option 3B1.

**2.7.3 Heritage issues**

The works would be similar to Option 2B3, and would have effects similar to that option. In addition, there would be continued effects of cycles of wetting and drying which would further destabilise archaeological deposits and probably cause ongoing erosion such as occurs at other inland lakes used for periodic water storage. These effects result in severe damage to archaeological material. The long-term effects are unknown but are probably negative due to wetting/drying cycles not allowing stabilisation of deposits.

**2.7.4 Economic benefits and costs**

Displayed in Table 2-6 are the estimated benefits and costs of Option 3B3 relative to the current situation.

**Table 2-6: Benefits and costs for Option 3B3**

<b>Benefits resulting directly from Option 3B3</b>		
<b>Item</b>	<b>PV at 4% (\$m)</b>	<b>PV at 8% (\$m)</b>
Water savings (@\$70/ML/year)	51.1	29.1
Commercial land use (based on agriculture)	0.05	-0.3
Savings in cost of water treatment in Shepparton	0	0
Savings in costs of algal blooms	0	0
<b>Costs associated with current operation not incurred under Option 3B3</b>		
Current management and operation costs avoided	12.5	7.1
<b>Total quantified benefits</b>	<b>63.7</b>	<b>36.0</b>

<b>Benefits resulting directly from Option 3B3</b>		
<b>Item</b>	<b>PV at 4% (\$m)</b>	<b>PV at 8% (\$m)</b>
Benefits of current operation given up under Option 3B3		
Loss of net economic value of recreation activities	4.7	3.1
<b>Extra costs associated with Option 3B3</b>		
Capital costs of works	22.1	21.3
Annual costs of works	11.8	6.5
Capital costs of offsets	47.1	45.4
Annual costs of offsets	2.6	1.4
Drainage costs	5.9	5.6
Bank rehabilitation costs	4.3	3.2
Wetland establishment costs	0.1	0.1
Buffer establishment costs	0.3	0.3
Wetland and buffer maintenance costs	0.3	0.2
<b>Total quantified costs</b>	<b>99.3</b>	<b>87.1</b>
<b>Net Present value</b>	<b>-35.7</b>	<b>-51.1</b>

***Unquantified benefits***

The recreation use benefits (such as, walking, and bird watching), the indirect use benefits (such as nutrient assimilation), and any non-use benefits of a large area of re-instated wetland. If the value of all benefits other than water savings (including the unpriced value of a re-instated wetland) were higher than assumed here they would need to have combined present value of \$35.7million at 4 per cent or \$51.1million at 8 per cent for the option to breakeven. These present values are equivalent to an annual value at 4 per cent (8 per cent) of \$1.7million per year (\$4.2million) for 50 years.

***Unquantified costs***

The potential for a once-off change in land values in the vicinity of the lake.

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### **Local effects**

Potential for a decline in local expenditure by recreationists in the range from about \$80,000 to about \$238,000 – midpoint about \$158,000. Local businesses supplying fishing requisites would absorb a significant proportion of this, say, about \$116,000.

The Lake Mokoan Caravan Park would be unlikely to be a viable business. The effects on other accommodation facilities have not been estimated but it is believed that they would be small.

### **Selected sensitivity analyses**

With the quantity of water savings given, the results suggest that the largest contributors to the net present value of the option are the rate of discount, the costs of works (including dam rehabilitation costs), the costs of offsets and the value of water savings. The costs are known with a greater degree of certainty than the value of water savings and the rate of discount. Therefore, the sensitivity of the results to these variables is investigated. At the request of the Study's Reference Committee, the effect of deleting dam rehabilitation costs os also investigated.

#### *Discount rate*

The results are sensitive to the rate of discount. This is because of the large costs that are incurred at the beginning of the project while the benefits are long lived. The higher the discount rate the smaller the present value of benefits but there is little change in the present value of costs.

#### *Value of water savings*

The above results were generated for a value of \$70/ML/year – corresponding to a capitalised value at 4 per cent (8 per cent) of \$1,500 (\$850). The breakeven values of water savings, that is, the value at which the present value of benefits would equal the present value of costs (net present value equals zero) would \$119/ML/year at 4 per cent and \$193/ML/year at 8 per cent. These correspond to capitalised values (over 50 years) of \$2,553/ML at 4 per cent and \$2,361/ML at 8 per cent.

#### *Without dam rehabilitation costs*

If dam rehabilitation costs are removed, the net present value at 4 per cent (8 per cent) is minus \$31.4million (minus \$48.1million). The breakeven value of water savings at 4 per cent (8 per cent) decreases to \$113/ML/year (\$185/ML/year). These correspond to capitalised values over 50 years of \$2,427 (4 per cent) and \$2,269 (8 per cent).

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## **2.8 Option 4. Revised operating rules for Lake Mokoan**

### **2.8.1 Description and costs**

The revised operating rules for Lake Mokoan are aimed at maximising the storage capacity and improving the water quality by increasing the filling rate above the current 1.5m per year, reducing the release capacity to 800ML/d and setting a minimum storage of 110GL.

The proposal requires no drainage works however, the full bank rehabilitation will be necessary. No offsets are required to maintain the system reliability. The estimated cost of the works required to allow Lake Mokoan to be operated at its current design capacity and under revised operating rules is about \$27million about the same as at present.

The revised lake operating rules will not produce water savings and will have no impact on the proposed new Warby development.

### **2.8.2 Environmental issues**

The 'Save Lake Mokoan Committee' (SLMC) put forward a proposal for revised rules for operating Lake Mokoan. These involved:

The 1.5m/year rule should be adhered to when draining the lake but the lake should be allowed to fill at a faster rate than 2m/year or more

Outflows should not exceed 800ML/day not only to preserve bed and banks but also to assist macrophyte migration

Every opportunity should be made to fill the lake to 100 per cent capacity

A minimum capacity of at least 30 per cent FSL, or 110GL should be adhered to so as to provide a source of flora and fauna to re-colonise the lake as it fills again.

The area of the lakebed subject to wave action of sufficient energy to resuspend lakebed sediments and increase turbidity would be reduced at the higher storage level. However, the distance across the lake which prevailing southwesterly winds can increase wave energy (i.e. the fetch) would remain high.

Filling the lake to 100 per cent of FSL at faster than 1.5m a year will make it more difficult for macrophytes to establish around the lake margin, as the plants may not have time to contribute to the seedbank before they are starved of light due to increased water depth. The amount of plant cover will be reduced on the shorelines possibly increasing shoreline erosion rates and increasing lake turbidity.

The net effects of greater depth but poorer vegetation on lake turbidity are not known at present.

Since there is no change to the configuration of the lake, no former wetlands would be restored under this option.

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No land will be made available for commercial use under this option.

No significant changes to the Lake Mokoan fishery are expected under this option unless the impact on macrophyte communities of rapid filling is greater than expected.

No significant changes to the Lake Mokoan waterbird habitat are expected under this option unless the impact on macrophyte communities of rapid filling is greater than expected. The possible greater uniformity of habitat may mean that waterbird species diversity is marginally decreased, but that overall bird numbers are similar to the current operation of Lake Mokoan.

The assessment of the possible conservation status of the lake and wetlands yielded the same result as described for Option 3B1.

The assessment of the possible conservation status of the lake and wetlands indicated that Lake Mokoan operated as described for Option 4 would not be likely to meet the same requirements for nationally significant wetlands as would Options 1, 2B1 and 2B3. However, given the large size of the Lake it is possible that it could meet the internationally significant wetland criteria number 5 (regularly supports more than 20,000 or more waterbirds). Further detailed assessment would be required to confirm whether the lake under Option 4 or existing operation could meet other national or international criteria for significance.

### **2.8.3 Heritage issues**

There would be essentially no change under this option. Nevertheless, there would be continuation of any current impacts, for example, waterlogging of archaeological deposits and features, and death and destruction of cultural scar-bearing trees.

### **2.8.4 Economic benefits and costs**

Displayed in Table 2-7 are the estimated benefits and costs of Option 4 relative to the current situation.

**Table 2-7: Benefits and costs for Option 4**

<b>Benefits resulting directly from Option 4</b>		
<b>Item</b>	<b>PV at 4% (\$m)</b>	<b>PV at 8% (\$m)</b>
Water savings (@\$70/ML/year)	-2.1	-1.2
Commercial land use (based on agriculture)	0	0
Savings in cost of water treatment in Shepparton	0	0
Savings in costs of algal blooms	0	0
Gain of net economic value of recreation activities	0.8	0.4
<b>Costs associated with current operation not incurred under Option 4</b>		
Current management and operation costs avoided	0	0
<b>Total quantified benefits</b>	<b>-1.4</b>	<b>-0.8</b>
<b>Extra costs associated with Option 4</b>		
Capital costs of works (connection to East Goulburn Main Channel)	9.6	9.3
Annual costs of works	1.6	0.9
Capital costs of offsets	0	0
Annual costs of offsets	0	0
Drainage costs	0	0
Bank rehabilitation costs	14.2	10.4
Wetland establishment costs	0	0
Buffer establishment costs	0	0
Wetland and buffer maintenance costs	0	0
<b>Total quantified costs</b>	<b>25.4</b>	<b>20.60</b>
<b>Net Present value</b>	<b>-26.8</b>	<b>-21.4</b>

**Local effects**

Potential for a gain in local expenditure by recreationists in the range from about \$16,000 to about \$48,000 – midpoint about \$32,000. Local suppliers of fishing requisites would benefit.

**Selected sensitivity analyses**

*Discount rate*

The results are not very sensitive to the rate of discount. This is because of the large cost of dam rehabilitation is incurred at the beginning of the project and the small increase in water losses are long lived.

*Without dam rehabilitation costs*

If dam rehabilitation costs are removed, the net present value at 4 per cent (8 per cent) is minus \$12.5million (minus \$10.9million).

**2.9 Summary Tables**

Table 2-8 summarises the likely water savings, costs and socio-economic implications of the options while Table 2-9 and Table 2-10 summarise likely environmental implications. The present values referred to in the table are discounted over a period of 50 years and are shown for a discount rate of 4 per cent (8 per cent).

**Table 2-8: Summary of Water Savings, Costs and Socio-economic Implications of the Options**

Item	Option 1 Return to Winton Swamp	Option 2B1 Spit bank, permanent storage, deep	Option 2B3 Spit bank, permanent storage, shallow	Option 3B1 Spit bank, annual storage, deep	Option 3B3 Spit bank, annual storage, deep	Option 4 Revised operating rules for Lake Mokoan
Water Savings (ML)	38,000	22,000	31,000	25,000	34,000	-1,400
Estimated present value of cost, including lost recreation and dam rehabilitation costs (\$m)	75.7 (68.8)	106.3 (92.6)	60.5 (50.9)	93.9 (80.8)	99.3 (87.1)	25.4 (20.6)
Estimated present value of cost per ML saved (\$/ML)	1,992 (1,811)	4,832 (4,209)	1,952 (1,642)	3,756 (3,232)	2,920 (2,561)	n.a.
Estimated present value of benefits (\$m)	78.6 (43.9)	57.2 (33.2)	67.8 (38.7)	49.1 (27.8)	63.6 (36.0)	-1.4 (-0.8)
Estimated present value of net benefit, including dam rehabilitation costs (\$m)	2.9 (-24.9)	-49.1 (-59.4)	7.3 (-12.2)	-44.8 (-53.0)	-35.7 (-51.1)	-26.8 (-21.4)

Item	Option 1  Return to Winton Swamp	Option 2B1  Spit bank, permanent storage, deep	Option 2B3  Spit bank, permanent storage, shallow	Option 3B1  Spit bank, annual storage, deep	Option 3B3  Spit bank, annual storage, deep	Option 4  Revised operating rules for Lake Mokoan
Estimated breakeven present value of water savings (\$/ML)	1,428  (1,512)	Approx. 4,200  (3,853)	Approx. 1,290  (1,398)	3,297  (2,980)	2,553  (2,361)	n.a.
Estimated present value of net benefit excluding dam rehabilitation costs (\$m)	n.a.  (n.a.)	-35.0  (-49.0)	11.6  (-9.1)	-30.6  (-42.7)	-31.4  (-48.1)	-12.5  (-10.9)
Estimated range of change in local expenditure by recreationists (\$)	-32,000 to -200,000 (mid-point -116,000)	+37,000 to +47,000 (mid-point + 42,000)	-40,000 to +44,000 (mid-point -2,000)	-60,000 to +9,000 (mid-point -26,000)	-80,000 to -238,000 (mid-point -158,000)	+16,000 to +48,000 (mid-point +32,000)
Storability of water savings	A range of limited opportunities exist	As for Option 1	As for Option 1	As for Option 1	As for Option 1	n.a.
Implication for proposed Warby Ranges development	Increases the present value cost of supply for Stage 1 by \$36million for the peak supply rate and \$19million for the average supply rate and Stage 2 by \$27million and \$16million respectively	Increases the present value cost of supply from Lake Mokoan to Stage 1 at the peak rate by \$10million and at the average rate by \$6million. The present value cost for supply to Stage 2 will increase by \$2.7 and \$1.4million respectively	As for Option 2B1	As for Option 2B1	As for Option 2B1	This option has no implications for the Warby development.
Heritage effects	Relative small effects due to minor disturbance; immediate effects of exposure and drying on waterlogged archaeological deposits (eg cracking of mound clays, vertical movement of artefacts); and rotting of exposed scarred trees.	As for Option 1, plus significant damage to the lunette, resulting in destruction of unquantified but predictably significant archaeological deposits – possibly burials	As for Option 2B1	As for Option 2B1 plus there would be some effects of cycles of wetting and drying which would further destabilise archaeological deposits.	As for Option 2B1 plus there would be continued effects of cycles of wetting and drying which would further destabilise archaeological deposits and probably cause ongoing erosion such as occurs at other inland lakes used for periodic water storage. These effects can result in severe damage to archaeological material.	There would be essentially no change under this option relative to current. Continuation of any current impacts, for example, waterlogging of archaeological deposits and features, and death and destruction of cultural scar-bearing trees.

The environmental scores in Table 2-9 and Table 2-10 show that Option 1 would entail the greatest change from the current condition of Lake Mokoan (that is, in configuration and operation) therefore it generates more positive and negative scores. Option 4, which would entail little change from the current condition, generates the fewest positive and negative scores. The other options are intermediate in the number of changes they would entail.

**Table 2-9: Summary of Positive Environmental Effects**

<i>Positives</i>	Option 1	Option 2B1	Option 2B3	Option 3B1	Option 3B3	Option 4	Comment
Dryland areas liberated for commercial use	2	1	1	1	1		Not really an environmental positive. More land made available under Option 1
Healthy seedbank known to be present down to 46% of FSL	2	2	2	2	2		
A portion of the former wetlands restored		2	2	2	2		
Low shear stresses and the stabilising effect of vegetation are expected to reduce turbidities	3	1	1				
Recreational fishery can be restored after construction and refilling		2	2	1			
The water surface area will also be reduced leading to a reduced fetch for potential wave action		2	1	1			
Minor benefits to native fish from the slightly more natural flow cycles in the Broken and Goulburn Rivers		1	2				
All former wetlands restored	3						
Shear stress on the swamp bottom is expected to be reduced due to the buffering effect of vegetation in the water	3						
The (re)establishment of a heavily vegetated wetland system is expected to have a greater potential for capturing nutrients exported from the Lake Mokoan Catchment	2						
The water regime should suit macrophytes which will out-compete algae for nutrients. Therefore algal blooms are not expected to be a problem	3	1	1				
The water surface area will also be reduced leading to a reduced fetch for potential wave action	2						
The more natural flow cycles in the Broken and Goulburn Rivers may benefit native fish	2						
Lower turbidity of Mokoan water likely with benefits to ecology of Broken & Goulburn Rivers	2						
Lower shear stresses due to greater depth may assist in reducing turbidities						1	
No construction impacts						3	
Recreational fishery largely unaffected						3	
Waterbirds largely unaffected						2	
<b>Total Positives</b>	<b>24</b>	<b>12</b>	<b>12</b>	<b>7</b>	<b>5</b>	<b>9</b>	

**Table 2-10: Summary of Negative Environmental Effects**

<i>Negatives</i>	<b>Option 1</b>	<b>Option 2B1</b>	<b>Option 2B3</b>	<b>Option 3B1</b>	<b>Option 3B3</b>	<b>Option 4</b>	<b>Comment</b>
Buffer strips will require fencing off from agricultural land	-2	-1	-1	-1	-1		More fencing required for Option 1 but not considered a significant environmental negative
Buffer strips will require revegetation including direct seeding and tubestock	-2	-1	-1	-1	-1		More fencing required for Option 1 but not considered a significant environmental negative
Localised high-risk areas for erosion around particular drainage lines including Show Creek	-1	-1	-1	-1	-1		The drainage lines are mainly to the east, therefore there is little difference in risk between the first 5 options
Soil of restored dryland areas likely to require restoration	-2	-1	-1	-1	-1		Greater area for soil restoration required for Option 1 but not considered a significant environmental negative
Uncertain condition of seedbank on dryland areas below 46% of FSL. This area may require sowing with pasture grasses to assist in erosion control	-1	-1	-1	-1	-1		Greater area to sow for option 1 but this is not considered to be a significant environmental problem
Wetlands may require revegetation to assist in restoration efforts	-1	-1	-1	-1	-1		Greater area to revegetate for option 1 but this is not considered to be a significant environmental problem
When the lake is drained, the exposed sediments may be highly erodible.	-1	-1	-1	-1	-1		This is scored as a minor negative for all options (except Option 4) due to the level of uncertainty attached
Recreational fishery destroyed during construction		-1	-1	-1			
Loss of recreational fishery	-3				-3		
Possible need for carp control in wetlands	-1						If some pockets of deeper water persist these may shelter carp. If this occurs, eradication and control methods should be initiated
Higher turbidities in the Broken River & Goulburn rivers may increase costs of water treatment at Shepparton				-1	-2		
Likely increased turbidities in the Broken & Goulburn Rivers with negative effects on river ecology				-1	-2		
Minor to moderate negative effect on waterbird habitat including hunted species for the lake area				-1	-1		
Negative impact on native fish in the Broken & Goulburn Rivers due to unnatural flow cycle (i.e. very high December and January flows)				-3	-3		
Water level regime likely to be too harsh for establishment of aquatic vegetation across much of the intermittently inundated or permanently inundated zones				-3	-3		
Likelihood of lake remaining in a turbid, algal dominated state				-2	-3		
No former wetlands restored						-3	
No land returned to commercial use						-3	
Rapid filling rates may impact on macrophyte communities						-2	
<b>Total Negatives</b>	<b>-14</b>	<b>-8</b>	<b>-8</b>	<b>-19</b>	<b>-24</b>	<b>-8</b>	



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The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between August 2002 and August 2003 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

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