GOULBURN BROKEN
CATCHMENT MANAGEMENT AUTHORITY

LOWER GOULBURN LEVEE AUDIT
MODIFIED FINDLAY SCHEME REPORT

Final

Prepared by

SMEC

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Executive Summary

Brief Outline of This Study

This report has been prepared as part of the Lower Goulburn Levee Audit, a consultancy which aims to determine the standard of protection currently offered by the levees on the Goulburn River downstream of Shepparton and evaluate floodplain management options.

The report describes the Modified Findlay Scheme (also referred to as Option 3) and evaluates it against an engineered solution (SKM's Option 2, May 1998). The Modified Findlay Scheme involves the acquisition of approximately 137 km^2 of land on the northern floodplain and the construction of bunds to form the Deep Creek Floodway which would be approximately 3 km wide.

Relative to Option 2, the Modified Findlay Scheme has many environmental and economic benefits. The benefit cost ratio of the Modified Findlay Scheme is substantially better than that for Option 2. Dis-benefits of the scheme include the potential social dislocation associated with the substantial land acquisition.

The Problem

The Lower Goulburn floodplain is located in north eastern Victoria between Shepparton and the Murray River close to Echuca. The Lower Goulburn is flanked by levees which were built at the turn of the century. These levees have been damaged by floods and repaired on approximately 10 occasions this century.

The current conditions constitute a problem for the community which can be described briefly as follows:

- The capacity of the river channel between the levees decreases substantially from Shepparton to Yambuna.
- This means that even in moderate floods (say 10-year ARI and greater) the levees are breached in numerous places and, in addition to on-farm damages, the levees need to be repaired. The average annual cost of levee repairs alone is approximately $74,000.

In the past, damaged levees were repaired using Natural Disaster Funds, but it has been advised that such funding will not be available in future unless the community has demonstrated a willingness to implement flood damage minimisation strategies.

It is the Goulburn Broken Catchment Management Authority's responsibility to adopt and implement an appropriate solution to this problem on behalf of the Lower Goulburn community.

What Is Happening Now

The existing levees, which were first constructed before the turn of the century, are generally located too close to the river channel. In select locations, on both sides of the river, outlet structures such as Loch Garry, release controlled amounts of flood water to the floodplain. The levees and outlet structures have the effect that:

- The capacity of the river is substantially reduced (compare 185,000 ML/d at Shepparton with 37,000 ML/d at Yambuna Choke);
- In large floods, which are not significantly attenuated, simple maths dictates flood water has to exit from the river channel onto the floodplain;
- Despite controlled releases at Loch Garry and elsewhere, in floods equal to or greater than approximately a 10-year ARI event, the levees either overtop or breach randomly. Substantial damage to agriculture, infrastructure and the levees results;
- In moderate floods, flow velocities between the levees are higher than they would be under natural conditions and erosion of the river banks is occurring at an increased rate. In places, bank erosion threatens the levees;
- Poor construction standards earlier in the century, and decades of only nominal maintenance, has left the levees in a generally poor state of repair with threats posed by trees, permeable materials, steep batter slopes, storm water erosion and cracks.

The Authority is currently implementing a waterway improvement program that aims to stabilise and restore the natural river regime. The Lower Goulburn Levee Audit is being undertaken and this will lead to a floodplain capital works program.

Minimalist Approach (Option 1)

A floodplain management approach available to the Authority is to minimise capital expenditure on the levees and therefor leave the levees virtually unchanged in terms of flood protection and flood damage repair costs. Actions under such an approach would include:

- Minor modification to the Deep Creek outlet structure;
- Removal of approximately 400 metres of redundant levee near Goddards Road;
- Inspection and maintenance of identified problem areas; and
- Repair flood damage to levees.

Although the initial capital expenditure under this approach is relatively small ($45,000), the annual average cost of maintenance and flood damage to the levees is substantial

($250,000 per annum). Also, **this approach may not be seen by the Government to constitute an adequate flood damage minimisation strategy.**

Engineered Solution (Option 2)

Another approach available to the Authority is to improve the engineering of the levees such that they are less susceptible to flood damage and provide more reliable flood protection. Option 2 would aim to achieve this by:

- Constructing six flood surcharge structures ($2.3million). These structures allow flood water to spill over the levees in large floods without damaging the levees;
- Relocating levees in five locations in order to eliminate significant "bottle necks" (capital cost $1.5 million);
- Replacing the Loch Garry gates with a mechanical system ($1.2million);
- Improvement of existing outlet structures ($400,000); and
- Levee repairs and upgrades ($1,31million).

In addition to the structural measures a raft of on-going management and maintenance measures would be implemented. Many of these are common to all Options.

Benefits associated with Option 2 include:

- Reduced annual average flood damage to agriculture;
- Reduced annual average damage to the levees.

By design this approach confines more flood water to the river channel by reducing the probability of levee failure. This represents a benefit in terms of reduced agricultural damage.

Dis-benefits associated with Option 2 include:

- Increased reliance on old levees for flood protection;
- Extensive levee damage would still occur in large floods, say 40-year ARI and greater;
- Accelerated river channel erosion due to increased flood flow in the river channel; and
- Greater sediment and nutrient loads delivered to the Murray River.

Modified Findlay Scheme (Option 3)

The Modified Findlay Scheme arises from the concept that the Deep and Bunbartha Creeks on the northern floodplain offer the most effective location for providing additional flood flow capacity. Elements of the Modified Findlay Scheme include:

- A large low level spillway at Loch Garry. Bars in the existing structure would be permanently removed ($300,000);
- Acquisition of much of the northern floodplain (approximately 13,700 ha) for the creation of the Deep Creek Floodway (DCF) by constructing levees approximately 3 km apart from Loch Garry to the Murray River. Some protection of the Murray Valley Highway is allowed for ($7,0million);
- Select levee relocations and upgrading ($1.31million); and
- An annual operation and maintenance program.

The cost of purchasing the land required for the DCF will be significant. In the economic evaluation only the management and administration of the land transfer are included as a cost.

The Modified Findlay Scheme has benefits that include:

- Reduced flood damage attributable to changing the land use in the flood prone DCF to forestry which is expected to be largely immune from flood damage;
- An effective increase in the standard of protection provided by the Lower Goulburn levees;
- The potential for additional flood outfall for the Broken Creek;
- Improved drainage outfall for southern floodplain drains;
- Reduced sediment and nutrient loads to the Murray River;
- Reduced rates of erosion in the Lower Goulburn river channel;
- Protection of a critical biolink zone.

The Modified Findlay Scheme has a potential dis-benefit in the social dislocation that could result from the substantial land acquisition. This activity would need careful management.

Economics

A provisional economic evaluation of Options 2 and 3 has been undertaken with a view to comparing their benefit cost ratios (BCRs). Benefits were taken to be those relative to existing conditions and include the net present value of reduced flood damage. Costs include the capital, operating and maintenance costs of implementing an Option. Details are provided in Table 7.3a and Table 7.3b in the body of the report.

For the purposes of the economic valuation, the land area in the DCF has been handled as follows:

- Direct land acquisition costs are not included;
- Management and administration costs of the purchase process are included;
- Future agricultural production forgone is included as a cost;

- Future flood damage averted is included as a benefit;
- Future production (or its equivalent) is included as a benefit

Flood damage reduction represents a significant difference between the benefits of Options 2 and 3. This arises from:

- Retirement from agriculture of large areas of flood (damage) prone land on the DCF; and
- An effective improvement of the levee standard (reduced flood damage) in non-DCF areas.

The capital cost of Option 3 is greater than that for Option 2 and this is mainly due to the cost of the DCF levees (conservatively estimated at approximately $7million).

On-going expenditure costs for Option 3 are similar to those for Option 2. Total on-going costs are dominated by estimates of the environmental costs and farm production forgone.

Although Option 3 has substantial ecological and environmental benefits associated with it, the results of the economic analyses do not depend on these benefits. In the "conservative" analysis, a numeric value of zero was assigned to all ecological benefits.

For the purposes of this study the waterway management programs for Options 2 and 3 were assumed to be broadly equivalent.

Benefit cost ratios (BCRs) were determined using a 100 year project life and a 4% discount rate. Some of the significant inputs to the analyses, such as flood damage reduction, capital cost of the DCF levee and effective change in the value of the land in the DCF, are estimates.

Results of the benefit cost analysis are presented in **Table E1**. Based on the benefit cost analysis, Option 3 is clearly a better option than Option 2, even if the "conservative" assumptions are used.

Table E1: Results of benefit cost analysis

Item	Description	B/C ration Option 2	B/C ratio Option 3
1	Most probable set of assumptions	0.74	1.96
2	Conservative set of assumptions	0.95	1.32

Where To Next

The investigation shows that the Modified Findlay Scheme is economically superior to both Option 1 and Option 2.

The next task for the Authority is to present these findings to the community. Following consultation and a submission period, the Authority will adopt an Option for implementation. Activities for implementation comprise:

1. Drafting a business plan;
2. Obtaining funding;
3. Carefully managing any land acquisition process to minimise community dislocation; and
4. Detailed design of the structural elements of the adopted Option.

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1. INTRODUCTION

The Goulburn River is Victoria's largest river. It rises in the high country north-east of Melbourne, north of the great dividing range, and drains to the Murray River. Lake Eildon is the major storage controlling the river and it supplies water to the large irrigation area in Northern Victoria.

The Lower Goulburn River is that part of the river located between Shepparton and its confluence with the Murray River at Kanyapella approximately 10 km east of Echuca, refer to **Figure 1.1**. The Lower Goulburn River traverses some 156 kilometres – though in a straight line is approximately 70 km. A system of levees that closely flank the river, have been in place since the turn of the century. These levees – their condition, the standard of service they provide and options for their future management – form the subject of this project.

In relation to their level of service, the leveed-river capacity (assuming no levee breaches) significantly reduces from approximately 185,000 ML/d upstream of Loch Garry to just 37,000 ML/d at Yambuna (Ref. 1). This means that the leveed-river system has to expel some 148,000 ML/d (assuming no attenuation) to the adjoining floodplains. This problem has long been the major concern since the construction of the levees.

The responsibility for the management of the Lower Goulburn Levees is not clear, but their construction was financed by Government. To date, the operation and maintenance of the levees have not been undertaken (refer to Section 3)

Following the 1993 Spring flood, a damage bill for the restoration of the levees was approximately $1M. Their restoration was financed from Natural Disaster Relief Funds from State Treasury. The allocation of funding was conditional upon the formation of the Lower Goulburn Waterway Management Authority (LGWMA) to resolve and implement a floodplain management strategy. The LGWMA now Goulburn Broken Waterways is a coordinating arm of the Goulburn Broken Catchment Management Authority (the Authority).

Sinclair Knight Merz was commissioned by LGWMA to prepare *The Lower Goulburn Waterway and Floodplain Management Plan,* which was completed in May 1998 (Ref. 1).

In February 1998 the Authority commissioned SMEC Victoria to undertake an audit of the levees with engineering evaluation of management options.

One of the options, the Modified Findlay Scheme, involves the removal of selected levees and part acquisition of land on the northern and southern floodplains. This report has been produced to serve as an interim report on the viability of this option, and is a progression of Sinclair Knight Merz' Scoping Study.

2. GEOMORPHOLOGY AND HISTORY

2.1 Geomorphic features of the floodplain

Figure 2.1 presents the Lower Goulburn Floodplain Geomorphic features including: natural levees, sand dunes ancestral course *etc.* The following description of the Lower Goulburn Geomorphology has been based on information contained in reference 1.

The Lower Goulburn is located in the Riverine Plain of the Murray River Basin. The Riverine Plain forms the surface of the eroded material that has slowly filled the Murray basin over the past 65 million years. (Ref. 11)

The modern Goulburn River has occupied its present course only for the past 10,000-15,000 years. The remains of a previous channel is now marked by Wakiti Creek while an earlier course, abandoned perhaps 25,000 years ago, ran from Shepparton via the present sites of Bunbartha and Kaarimba to the present course of the Broken Creek (refer to Tallygaroopna ancestral river in **Figure 2.1**). These ancestral systems are associated with relatively high natural levees, which influence flood flows escaping to the Murray River, particularly the Wakiti Creek.

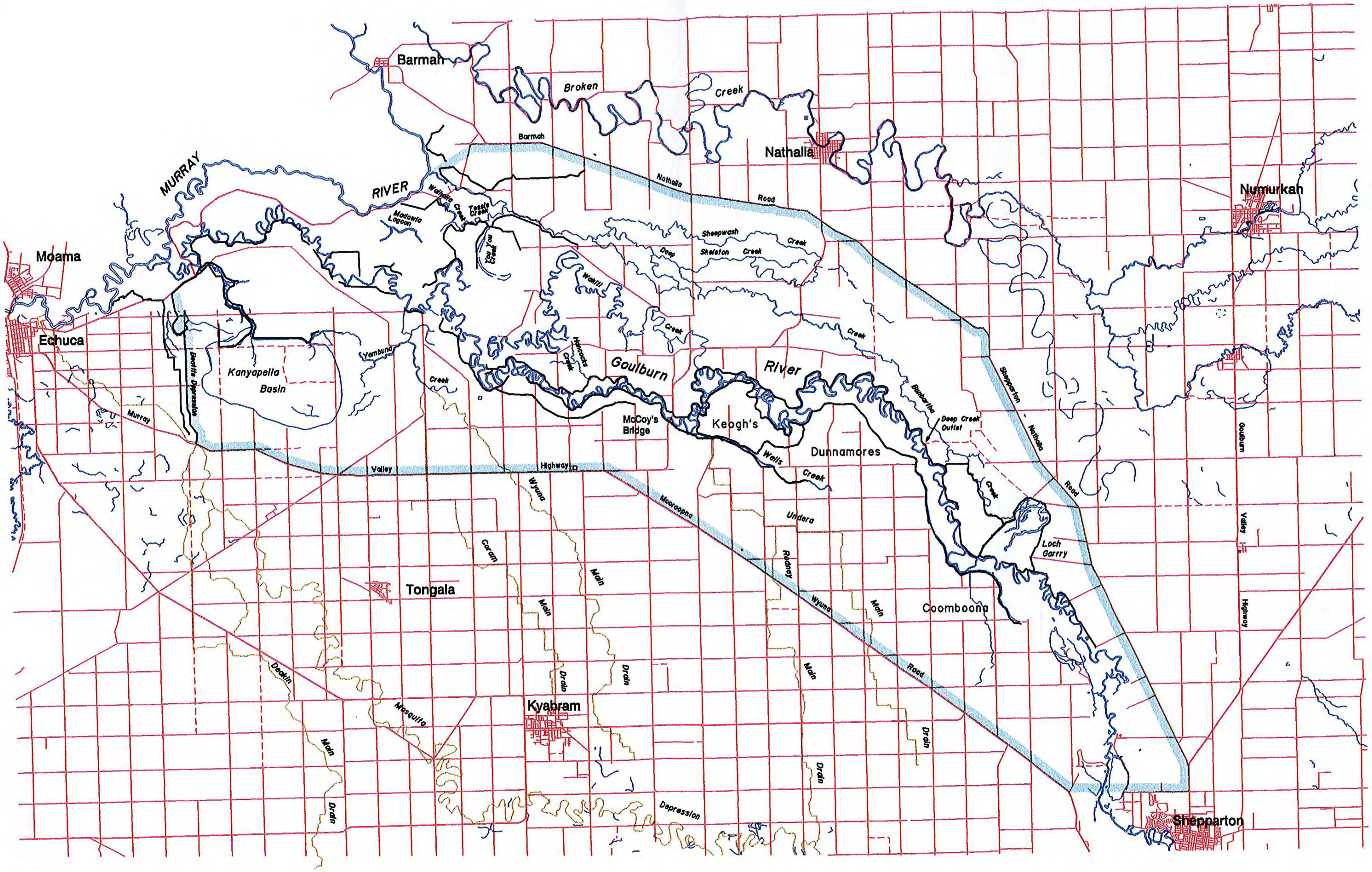
Other features that significantly influences flood flows escaping to the Murray River are the Bama Sandhills. Lake Kanyapella, an ancient lake which is now dry, led to the creation of the Bama Sand Hills, a lunette deposit on the north-eastern shore of the former lake (see **Figure 2.1**). Flows from the present Goulburn River can only pass through four openings in the Bama Sandhills:

- at Yambuna on the present course of the Goulburn River (known as Yambuna Choke);
- through the Murray River from overflows from the Goulburn River via Deep Creek (known as the Barmah Choke);
- through a flood course associated with the Madowla Lagoon; and
- at high river stage, along Yambuna Creek to Kanyapella Basin

Throughout much of the study area, the Goulburn River is now bordered by a near-channel floodplain approximately two kilometres wide, which generally corresponds to the meander belt of an ancestral course of the Goulburn River.

Upstream of Loch Garry, the near-channel floodplain is at a lower elevation than the surrounding terraces and drainage from the terraces tend to flow towards the river.

Downstream of Loch Garry, however, the near-channel floodplain is separated from the broader floodplain by natural (and artificial) levees. Moreover, rather than flowing north, directly down the slope of the Riverine Plain to the Murray, the Goulburn traverses the plain to the north-west. Flood flows escaping from the river channel on the north bank generally drain north away from the river, following the slope of the Riverine Plain to the Murray River. A number of ephemeral waterways have developed to collect these breakaway flows and convey them to Deep Creek. These include Bunbartha Creek, Skeleton Creek and Sheepwash Creek. Flood flows from Deep Creek outfalls to the Murray about 7 km downstream of Barmah.



LEGEND

STUDY AREA BOUNDARY

EXISTING LEVEES

0 5 10
SCALE OF KILOMETRES

CICS PTY LTD

TOPOGRAPHIC DATA LICENCE LAND VICTORIA (DNRE)
PROJECT NO 750 - PREPARED 30 JUNE 1998

SMEC

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GOULBURN
BROKEN
CATCHMENT
MANAGEMENT
AUTHORITY

FIGURE 1.1 STUDY AREA

jebllglm8

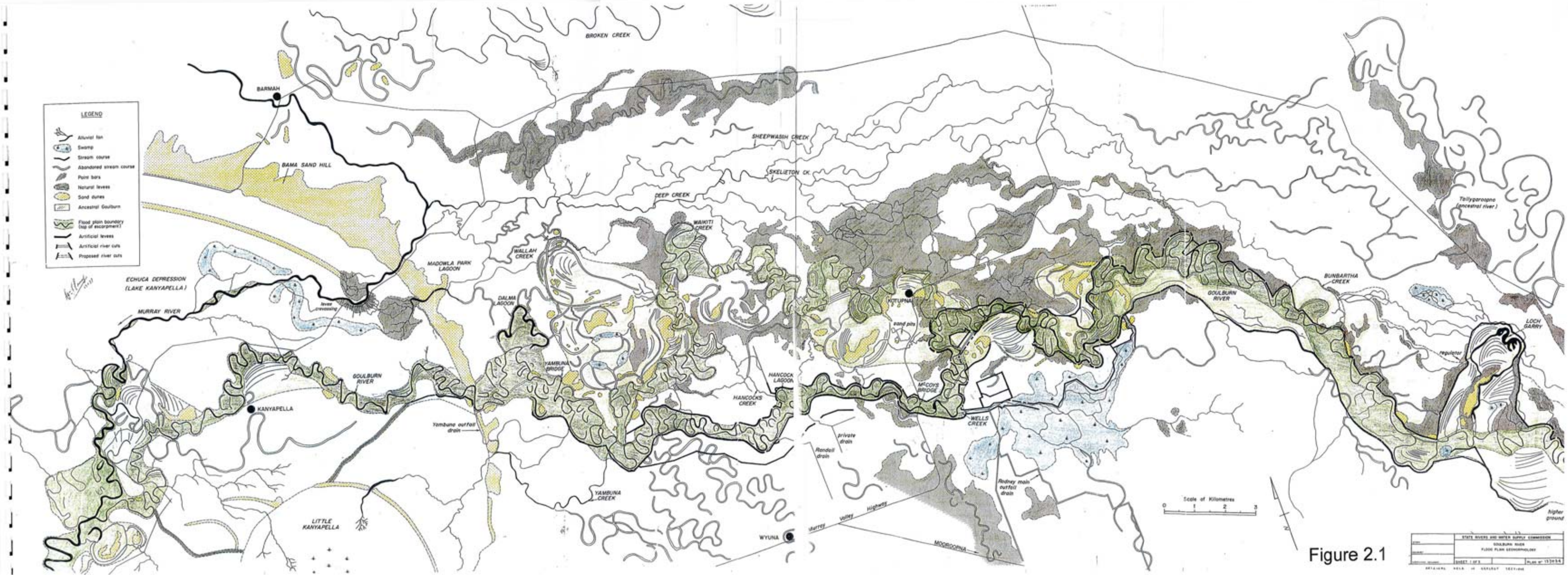

LEGEND
Alluvial fan
Swamp
Stream course
Abandoned stream course
Point bars
Natural levees
Sand dunes
Ancestral Goulburn
Flood plain boundary (top of escarpment)
Artificial levees
Artificial river cuts
Proposed river cuts
BARMAH
BROKEN CREEK
BAMA SAND HILL
ECHUCA DEPRESSION (LAKE KANYAPELLA)
MURRAY RIVER
levee crevassing
MADOWLA PARK LAGOON
WALLAH CREEK
DALMA LAGOON
YAMBUNA BRIDGE
SHEEPWASH CREEK
SKELETON CK
DEEP CREEK
WAIKITI CREEK
GOULBURN RIVER
KANYAPELLA
Yambuna outfall drain
LITTLE KANYAPELLA
YAMBUNA CREEK
HANCOCK LAGOON
HANCOCKS CREEK
WYUNA
KOTUPNA
sand pits
McCOYS BRIDGE
WELLS CREEK
private drain
Randall drain
Murray Valley Highway
Rodney main outfall drain
MOOROOPNA
Tallygaroopna (ancestral river)
BUNBARTHA CREEK
LOCH GARRY
regulator
higher ground
Scale of Kilometres
0 1 2 3
STATE RIVERS AND WATER SUPPLY COMMISSION
GOULBURN RIVER
FLOOD PLAIN GEOMORPHOLOGY
SHEET 1 OF 3

Figure 2.1

Flood flows breaking out from the south bank of the Goulburn River are unable to escape to the south and are partly blocked from returning to the river by natural (and constructed) levees. Wells Creek is the main watercourse which collects breakaway flows on this side of the river, and drains back to the Goulburn just upstream of McCoys Bridge on the Murray Valley Highway.

In addition to the above, the following ancient and modern features of the Lower Goulburn have important consequences for the present management of the river and the floodplain:

- The low gradient of the Riverine Floodplain and the river's tendency to traverse the slope of the Riverine Plain rather than flow down it have created a river that has historically discharged a large portion of flood flows before they reach the lower end of the river's course. As floodwaters were discharged to the floodplain their energy was not available to enlarge the river's channel and this steadily diminishes in capacity between Loch Garry and the Murray River.
- The Modern Goulburn River is reworking sediments left behind by its ancestral stream. The newer sediments are more erodible than the older heavy clays and partly consolidated rocks of the most ancient stream deposits. In places, these older deposits now provide bed level control of the modern river and influence bank processes and erosion rates.
- The Goulburn River's inclination to change course across the Riverine Plain has not ended. Diminishing downstream flow channel capacity, eroding floodpaths and distributary creek potentially encourage the development of alternative courses capable of diverting the river by avulsion or breakaway. This risk is increased if the ground surface is exposed by vegetation clearance or vehicle damage, or if flood flows are concentrated as a result of drainage or flood mitigation works.
- Many of the wetlands within the Lower Goulburn floodplain occupy ancient river courses (eg, large oxbow lakes such within Loch Garry, and at Delma Lagoon). Because these wetlands are a relic from a time when the landscape and climate were different, they will not be replaced by natural processess if they are now destroyed.

2.2 Brief History and "No Agreed" scheme

The Lower Goulburn has been extensively modified. The floodplains have been cleared for agriculture and grazing. The south side includes established irrigation and drainage infrastructure with its network of roads. Dryland agriculture and grazing occupy the floodplain to the north with a small proportion of irrigation (Ref. 1).

Following several flooding episodes in the 1880s (Ref. 8) a committee was set up on the "eastern side." A petition to government was prepared requesting assistance to construct a levee scheme. When landholders on the "western side" awoke to the fact that levees were being considered they had the government veto the scheme.

Several years followed where a local dispute over a levee in Yambuna occurred. A Mr George Stickels (Ref. 8) saw this to be an opportunity to call for a conference of the interested shires of "Deakin, Rodney, Shepparton and Numurkah." Within a few days of a deputation asking that the unemployed be set to work to construct levees, "men with barrows and tools" were at work constructing levees.

According to the news article (Ref. 8) it is understood the engineers were instructed to save all the land they could. The engineers Messrs Muntz and Bage set out the levee scheme whereby no levees were to be nearer than seven chains (approximately 140 m) from the river and in no case were the river bends to be followed. The levees constructed, as they exist today clearly do not conform to the engineers' criteria.

A 1968 report on The Goulburn River Flooding Inquiry (reference 11) highlighted that the Government would not be involved in the levee scheme (not including Loch Garry) until landholders in the area of benefit agreed to the scheme including the payment of a flood protection rate.

In October 1987, Cameron McNamara Consultants were commissioned to investigate structural and planning measures (reference 5) to best mitigate the effects of flooding in the Lower Goulburn. In essence the report recommended a series of spillways in the levee system. The report contains correspondence from the affected municipal councils where agreement of the recommended scheme could not be reached. This scheme subsequently was not carried out.

Following the Spring floods of 1993, the State Government provided Natural Disaster Relief Funding provided that a Waterway Management Authority was set up to prepare a floodplain management plan for the area. The Lower Goulburn Waterway Management Authority were established (now Goulburn Broken Waterways which is a co-ordinating arm of the Authority), in which it commissioned Sinclair Knight Merz to carry out the study. In May 1998, the Lower Goulburn Waterway and Floodplain Management Plan was finalised (reference 5) – refer to Section 5.

The report outlined two options for floodplain management; a minimalist approach (Option 1) and a scheme with a series of Flood Surcharged Structures within the levee system (Option 2). A third option (Option 3) briefly examined the possibilities of levee removal. This Option is outlined in the Scoping Study (Ref. 2), which concluded that there is no legal or technical reason why such a scheme could not proceed, provided consultation is undertaken.

3. EXISTING CONDITIONS IN THE FLOODPLAIN

3.1 Current Levee System

The levee system constructed within the Riverine Plain as describe in Section 2 means that the flow capacity of the leveed-river system would also progressively diminish downstream which is the main problem that is still faced today.

Table 3.1 illustrated the flow capacity of the leveed-river at specific sites along the Goulburn River.

Table 3.1: Flow Capacity of Leveed-River (assuming no levee failure) – [Ref. 1]

River Location	Flow Capacity		Peak Water Level	ARI/ AEP [2]
	(ML/d)	(m^3/s)	Shepparton Gauge (ft/m)[1]	
Upstream of Loch Garry to Medland Road	185,000	2,140	39.5/12.03	40y/2½
Loch Garry to Deep Creek Outlet	85,000	980	36.0/10.97	7y/15%
Deep Creek outlet to u/s of McCoys Bridge	75,000	870	35.5/10.82	5y/20%
McCoys Bridge	65,000	750	34.9/10.65	4y/25%
D/s of McCoys Bridge to u/s of Yambuna Forest	60,000	720	34.7/10.56	3y/30%
Yambuna Choke	37,000	425	32.9/10.01	2y/50%

1 Determined from Current Rating Table at Shepparton Gauge Station 405204C (Ref. 10)

2 Average Recurrence Interval/ Annual Exceedence Probability – Determined from Reference 9. Frequency analysis carried from 1921 to 1993 and include the historical 1916 flood.

Table 3.1 demonstrates that between Loch Garry and Yambuna the system must expel some 147,000 ML/d (assuming no attenuation) via existing outlet structures and random levee failures.

The levee system does to some degree provide outflows via outlet structures, but with limited capacity as presented in **Table 3.2.**

Table 3.2 Estimated Outlet Capacities – [Ref. 1]

Outlet	Outlet Capacities	
	(ML/d)	(m^3/s)
Loch Garry Regulator	60,000	695
Deep Creek Outlet	3,000	35
Wakiti Creek Outlet	3,100	36
Hagens Pipe Outlet	100	1
Hancocks Creek Outlet	3,700	43

3.2 Flooding

As described under Sections 2, the levees, in various forms, have been in place since before the turn of the century. No comprehensive set of flood maps exist for conditions prior to the construction of the levees. To obtain a comprehensive and accurate set of flood inundation plans for the floodplain prior to levees would require detailed hydraulic modelling which would be costly.

Floodplains change over time and the mapping task could be further complicated by the issue of how the river and floodplain morphology might have changed due to natural processes, but was prevented from doing so by the levee system, and visa versa.

However, for the purposes of comparison only, estimates of areas inundated in "natural" or "pre-levee" conditions, based on the areas inundated under existing conditions have been made and are presented in **Tables 3.3 and 3.4.**

Table 3.3 **Areas Inundated Under Natural and Existing Conditions (ha)**

REGION [1]	Land subject to 5 year inundation		Land subject to 20 year inundation		Land subject to 100 year inundation	
	Pre-levee	Existing	Pre-levee	Existing	Pre-levee	Existing
Coomboona	930	635	1760	1170	1860	1860
Undera	2300	1800	6550	5550	6950	6950
Wyuna	845	320	2770	1720	3870	3870
Kanyapella	2500	0	7180	1800	11745	11365
Madowla Lagoon	5080	4580	6580	6292	8303	8115
Kotupna	4800	3200	11375	8175	13050	12950
Bunbartha	6325	3800	11063	10288	13201	12926
Shepparton	975	0	2185	235	2385	1385
TOTAL	**23755**	**14335**	**49463**	35230	**61364**	**59421**

1. The regions referred to are not necessarily equivalent to Parish boundaries.

Table 3.4: Benefits in term of reduced area inundated (ha)
(Benefit = Pre-levee – Existing)

REGION	5year	20 year	100 year	High Ground	Totals
Coomboona	295	590	0	0	885
Undera	500	1000	0	0	1500
Wyuna	525	1050	0	0	1575
Kanyapella	2500	5380	380	0	8260
Madowla Lagoon	500	288	188	88	1064
Kotupna	1600	3200	100	0	4900
Bunbartha	2525	775	275	0	3575
Shepparton	975	1950	1000	0	3925
Totals	**9420**	**14233**	**1943**	**88**	**25684**

Estimated areas of inundation for the 5 and 20-year ARI were derived from flood mapping contained in reference 5.

Estimated areas of inundation for the 100-year ARI were determined from the Reference 6. This reference shows flooding north of the Shepparton Barmah road which is outside the defined study area.

3.3 Loch Garry Regulator

The Lock Garry Regulator and its associated levees are currently owned and operated by Goulburn-Murray Water.

The works were originally proposed as the *Loch Garry Minor Flood Protection Scheme* to provide relief from minor flood events, and was designed to protect Bunbartha/Deep Creek and the adjoining floodplain from flooding by overflows through the Loch until the river reached a height of 34 feet (10.36 m approximately 50,000 ML/d) on the Shepparton Gauge. The Loch Garry regulator comprises a concrete structure with 48 bays, each about 2.2 metres wide, which contains slots that enable stop logs (or bars) to be inserted or removed as required (Ref. 5)

Current regulation prescribe the progressive removal of a proportion of the bars 24 hours after the flood stage at the Shepparton Gauge reaches key levels. Bars are manually lifted, and once 36 feet (10.96 m approximately 85,000 ML/d) is exceeded at the Shepparton Gauge all bars are removed. The Loch therefore offers protection against nuisance flooding up to a 2.5 year ARI (34 feet) and partial protection up to a 7-year ARI flood (36 feet). (References 5, 9 and 10)

The Loch Garry regulator is the most upstream outlet in the Lower Goulburn River and has the largest outflow capacity of 60,000 ML/d as indicated in **Table 3.2**. Its operation is therefore crucial to the Lower Goulburn floodplain management. Without the releases at

Loch Garry, the capacity of the river would be limited to approximately a 5-year flood upstream flood of McCoys Bridge.

The Loch Garry regulator is a regulated structure with a defined set of operation rules that were established in 1932. The 119 members of the Loch Garry Flood Protection District (established in 1925) contribute approximately $30,000 per annum to operate and maintain the system. Refer to **Figure 6.2** (the A1 sized drawing in the back pocket) for district boundary. In the 1993 flood (approximately a 30-year ARI flood) the flood level reached the crest of the levees at Loch Garry. It is likely therefore that in a larger flood, the levees at Loch Garry would sustain damage. It is not evident whether the average annual cost associated with damage sustained in very large floods has been allowed for in the scheme's $30,000 operation and maintenance fee.

3.4 Deep Creek Outlet

The Deep Creek Outlet releases floodwaters to Bunbartha Creek which is part of the Deep Creek system on the northern floodplain. The original outlet structure was reconstructed in 1980 to a greater capacity than the original structure (Ref. 1). It was subsequently modified by local landowners without approval by Lower Goulburn Waterways, i.e. "illegally" (Ref. 1, page 22). The modification comprises stop logs which can reduce the capacity of the outlet.

3.5 River Capacity

The flood of 1981 caused damage to the levees, although details are scant. The 1981 flood had a peak at Shepparton of approximately 87,300 ML/d (Ref. 1, p33). This flood was somewhat smaller than a 10-year flood and is estimated to be approximately a 7-year ARI flood. It can therefore be deduced that, unless repairs to the levees since the 1981 flood had the effect of significantly increasing their standard of service (which is considered unlikely), the standard of the levees provide less than a 10-year level of service (105,000 ML/d or 11.24m / 36.9 ft on the Shepparton gauge). The 1981 flood has significance because a comprehensive set of flood data exist and this was used in the floodplain modelling undertaken by Cameron McNamara in 1987 (Ref. 5).

Given that the capacity of the levee system is relatively small, the flow capacity of the river between the levees is a significant input to the evaluation process. Flow capacities are provided in **Table 3.1** in Section 3

It follows that, unless the capacity of the channel is substantially increased, flood flows will be redistributed to the floodplain in relatively frequent events such as a 10-year flood. The location of the redistribution points could either be at designated locations where the levee is protected against damage (i.e. FSSs if they exist) or at random locations where the levees either fail or are overtopped.

Of interest is that in a 10-year flood of approximately 105,000 ML/d or 1,215 m^3/s, and 11.24 metres or 36.9 feet at the Shepparton Gauge, the river channel at McCoys Bridge can accommodate approximately 40% of the flow at Shepparton, refer **Table 3.1.**

3.6 Operation and Maintenance of the Floodplain

Formal operation and maintenance of the Lower Goulburn floodplain and its associated levees and outlet structures appears to be have been limited to:

- the operation of the Loch Garry scheme; and
- sporadic repairs to the levee system after significant floods. In the past, the costs of such repairs have been borne by Natural Disaster Relief Funding (Sate and Federal).

It is understood that routine surveillance and maintenance of the levee in the past has been neglected (Ref. 1 p 76). Effectively, the only maintenance undertaken has been under the guise of post flood repairs. Determination of the annual operation and maintenance cost cannot be based on past activities and expenditure.

In future, activities comprising operation and maintenance would include:

- maintenance of the system;
- specific realignments of levees to avoid future failure by river erosion;
- modification of the Deep Creek outlet;
- modification of the levee near the Goddards Road area;
- repairs of damage following large floods; and
- the costs of monitoring the levees (inspections).

4. OPTION 1 – MINIMAL ACTION

4.1 Description of Option 1

Option 1 (called "Strategy 2" in Ref. 1) is a "minimalist" approach to management of the floodplain. It is different from a "do nothing" option in which levees would not be maintained or repaired after floods. Option 1 is described in detail in Section 5.2 of reference 1 and comprises works and maintenance as follows:

Capital works

- Deep Creek Outlet: The structure is to be restored to the 1980 design.
- Loch Garry: No structural changes. The operation rule is to be amended such that bars are removed from the structure sooner. The payment of levies by landowners in the Loch Garry Flood Protection District will be discontinued following the transfer of the Loch Garry infrastructure.
- Keogh's and Cooks Spillways: These spillways are located on the south side just upstream (east) of the Wells Creek confluence. Approximately 400 m of levee located close to the spillways would be removed.

Operation, Maintenance and Monitoring

- Declaration of floodways along Bunbartha Creek, Skeleton Creek, Deep Creek, Sheepwash Creek, You You Creek, Tessie Creek, Walalla Creek.
- Flood Warning System: The Authority is to connect to the existing telemetry system and additional gauges are to be added to the telemetry system. The Authority is to chair the Lower Goulburn Flood Warning Reference Group (LGFWG) Monitoring. The discharge at the outlet structures during moderate floods should be measured. Staff gauges should be installed. Cable ways should be installed at the proposed Coomboona and Yambuna outlets. Aerial photography of flood extent and survey of flood levels after major floods.
- Inspection and maintenance of identified problem areas.
- It should be noted that many activities and capital works, such as river bank stabilisation and relocation of levees that are located very close to the river, are considered under Waterway Management. The program for waterway management is understood to be largely common to all options. It is covered in Section 6 of reference 1.

4.2 Costs and Benefits of Option 1

The estimated costs and benefits for Option 1 are presented in **Table 4.1**. Costs are divided into categories of initial capital expenditure and on-going operation and maintenance. Most of the costs are those presented in Reference 1.

There will be benefits attributable to the works undertaken in Option 1, however, since it is not required at this stage to determine the benefit-cost ratio of "existing conditions" (Option 1), the benefits have not been quantified.

Table 4.1. Option 1 Costs and Benefits.

Item	Description	Capital cost	Annual cost
1	COSTS		
1.1	Deep Creek outlet modification	$3,500	
1.2	Monitoring equipment	$32,000	
1.3	Removal of levees at Keoghs	$10,000	
1.4	Annual maintenance cost		$180,000
1.5	Annual average levee repair costs		$74,000
1.6	Annual monitoring cost		$22,000
	TOTALS	**$45,500**	**$276,000**

5. OPTION 2 - ENGINEERING SOLUTION

5.1 Description of Option 2

Option 2 is called "Strategy 2" in reference 1 and is described in detail in section 5.3 of that document. The approach of Option 2 is to modify and upgrade existing assets to reduce flooding to the community as a whole. All the measures in Option 1 (initial capital works and operation and maintenance) are included in Option 2. The measures included in Option 2 are listed below:

5.1.1. Capital Works

Capital works would comprise:

- Relocation of select levees to increase the flow capacity between the levees (refer to **Figure 5.1**);
- Upgrading of the levees. The relocated levees will be constructed to new standards so only the non-relocated levees will need structural repairs and/or raising to a consistent level or standard;
- Improved drainage outfall to the Goulburn on the south bank (Wells Creek area and Wyuna);
- Installation of new Flood Surcharge Structures (FSSs) on both sides of the river. These are listed below:
    1. Coomboona (south bank)
    2. Loch Garry (additional structure next to existing structure)
    3. Bunbartha Creek (north bank)
    4. Dunnamores Creek (south bank)
    5. Delma Lagoon (north bank)
    6. Rodney Main Drain Outfall
    7. Medland Road (optional, north bank)

- Development of floodways outside the levees such that obstructions (such as roads) in the floodways are minimised
- Replacement of the Loch Garry stop logs with gates
- Restoration of the Deep Creek outlet to the 1980 design

5.1.2. Operation, Maintenance and Monitoring

Activities and works under on-going operation, maintenance and monitoring include:

- Declaration of floodways along Bunbartha Creek, Skeleton Creek, Deep Creek, Sheepwash Creek, You You Creek, Tessie Creek, Walalla Creek;
- Flood Warning System: The Authority is to connect to the existing telemetry system and additional gauges are to be added to the telemetry system. The Authority is to chair the Lower Goulburn Flood Warning Reference Group (LGFWG);
- Monitoring. The discharge at the outlet structures during moderate floods should be measured. Staff gauges should be installed. Cable ways should be installed at the proposed Coomboona and Yambuna outlets. Aerial photography of flood extent and survey of flood levels after major floods; and
- Routine inspection and maintenance of identified problem areas.

5.2 Costs and Benefits of Option 2

One of the benefits of Option 2 is the reduction of flood damage in the floodplains. The areas inundated for the 5-year, 20-year and 100-year ARI floods, broken down into their land use categories are presented in **Table 5.1**.

Table 5.1: Option 2 Areas Inundated (ha)

It should be noted that the values in the table include flood prone land north of the Shepparton Barmah Road which is outside the nominated study area.

LAND USE	5 YEAR INUNDATION		ADDITIONAL 20 YEAR INUNDATION		ADDITIONAL 100 YEAR INUNDATION		**TOTAL 100 YEAR INUNDATION**	
	Option 2	Existing	Option 2	Existing	Option 2	Existing	Option 2	Existing
State Forest	5760	6,400	1035	1150	117	130	**6912**	**7680**
Private Forest	1008	1,120	1206	1340	144	160	**2358**	**2620**
Private non-irrigated	5120	6,400	10788	13,220	9899	10670	**25807**	**30290**
Irrigation mixed	328	410	2614	3,180	6666	7405	**9608**	**10995**
Dairy, Pigs, high capital	152	190	1520	1,900	4224	5280	**5896**	**7370**
Horticulture	0	0	30	30	35	35	**65**	**65**
Special use	10	15	60	80	180	200	**250**	**295**
TOTAL	**12378**	**14535**	**17253**	**20900**	**21265**	**23880**	**50896**	**59315**

The values presented in **Table 5.1** have been used by Read Sturgess and Associates (RSA), to derive the annual average flood damage reduction for Option 2 relative to existing conditions. A comprehensive description of the determination of the benefits is contained in Appendix A.

The costs and benefits of Option 2 are listed in **Tables 7.3a** and **Table** 7.3b. The costs and benefits are described in more detail in reference 1.

6. OPTION 3 - MODIFIED FINDLAY SCHEME

6.1 Introduction

The "Findlay Scheme" was first conceived as far back as 1908 by Mr J G Starr (Ref. 3). His suggestion was for the Bunbartha, Deep and other Creeks be used to convey floodwaters to the Murray. Levees, one mile apart, would be constructed from Loch Garry to the Murray River.

In the early 1920s Mr J Findlay, a landowner on the south bank, proposed the scheme to the State Rivers and Water Supply Commission. At first the scheme enjoyed community support but when the cost estimates were completed, it was rejected by a large majority because it was not deemed to be as economically attractive as the Loch Garry scheme. This was at least in part due to the high cost of land acquisition. It would seem likely that some benefits of this scheme such as:

- the reduced annual average damage cost to the levee system; and
- enhanced environmental values associated with the restoration of forests on the flood prone part of the northern floodplain;

were not considered in the evaluation at that time.

6.2 Modified Findlay Scheme

The philosophy of the Modified Findlay Scheme arises from the following considerations:

- The flow capacity within the existing levee system is limited and damage to the levee is likely in floods greater than approximately a 10-year ARI flood (105,000 ML/d and 11.24m or 36.9ft at the Shepparton Gauge);
- Although the levees could be raised to a design standard of, say, the 20-year ARI flood (approximately 140,000 ML/d and 11.6 m or 38.1 ft at the Shepparton Gauge) this would be costly. The FSSs in such a system would allow inundation of farm land on both sides of the river during floods in excess of the design standard. Raising the levees and confining flood flows to the river channel would further accelerate the degradation of the river channel through increased rates of erosion. This process would also adversely affect the levees themselves i.e. accelerate the rate at which river bank erosion tends to undermine the levees where they are located close to the channel. Other environmental costs of raising the levees arise from delivering more sediments and nutrients to the Murray River;
- There therefore seems to be merit in "creating" additional capacity in designated floodways on the floodplains, the issue being to identify the most appropriate locations.
- Geomorphological considerations (refer to Section 2 and **Figure 2.1**) suggests the north bank has better potential for floodways than its counterpart on the south bank because
  - The existing creeks (Bunbartha, Deep, Skeleton, Sheepwash, Tessie) provide flow capacity and a low flow channel.
  - A south bank floodway from Coomboona to the Murray at Warrigal Creek would be approximately 8 km longer than a floodway on the north bank. Accordingly it would involve more land acquisition. It would need to cross high ground at Emily Jane Road, Wyuna, and this would add to the costs.
- Geomorphological considerations (refer to Section 2 and **Figure 2.1**) indicates that no adverse impacts is likely to occur on the Murray River (refer to Appendix B).

The Modified Findlay Scheme comprises the following elements (refer to **Figure 6.1**):

- Construction of a large low level spillway (or removal of Loch Garry and some associated levees) to allow floodwaters to enter the Deep Creek Floodway.
- Removal of levees at the inflow to Loch Garry at the Goulburn River (if detailed design identifies a need)
- Removal of levees near Goddards Road to allow flooding of land in the Wells Creek area;
- Acquisition of land on the north bank in the "Deep Creek Floodway" (refer to **Figure 6.1**)
- Construction of banks (or levees) to contain flood flows in the Deep Creek Floodway.
- Repairs and upgrading of levees on the south bank to provide an even standard of protection;
- A waterway management program similar to Options 1 and 2;

A plan showing the titles and landowners on the northern floodplain from Loch Garry to the Murray River has been prepared and is presented as **Figure 6.2.** This figure also shows the boundary of the Loch Garry Flood Protection District.

The selected location of the major, low level spillway into the Deep Creek Floodway is at Loch Garry. This site has been selected in preference to removing levees in the vicinity of the existing Deep Creek outlet because:

- Flood levels opposite Loch Garry at Coomboona, and those between Loch Garry and the existing Deep Creek outlet, will experience an improved standard due to reduced flood flows between the levees;
- Loch Garry is a "tried and tested" location for flood waters to enter the Deep Creek Floodway (e.g. 1993 flood).

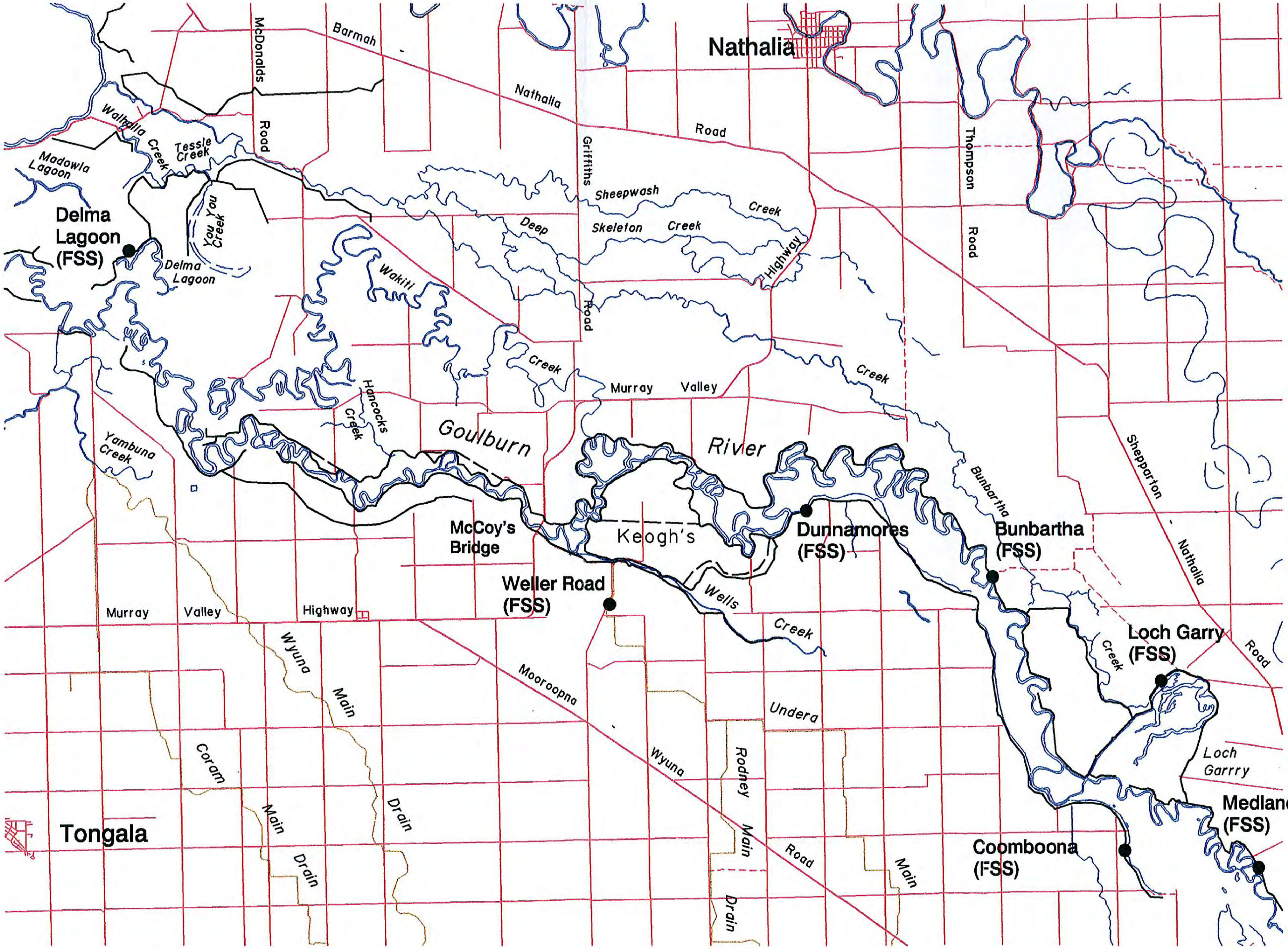
6.3 Costs of the Modified Findlay Scheme

The costs of the Modified Findlay Scheme include:

- Future farm production foregone in the Deep Creek Floodway. This arises from the change in land use from agriculture to more flood prone River Red Gum forests;
- Capital cost of managing the land acquisition process (this is different from land acquisition costs)
- Capital cost of constructing levees on both sides of the Deep Creek Floodway;
- Capital cost of relocating a levee in the Goddards Road area;
- Future farm production foregone on the south bank in the Goddards Road area;
- Capital cost of construction of a low level spillway at Loch Garry;
- Repairs and/or raising of levees to a consistent standard (similar to Option 2);
- Annual maintenance cost
- Annual average levee repair costs
- Annual monitoring cost

Refer to **Table 7.3a** and **Table 7.3b** for details.

It should be noted that for the purposes of the economic evaluation, land acquisition is not included as a cost. The land is not lost; land ownership is transferred. The change in land valuation associated with change in land use is included in the economic evaluation, refer to Section 7. An allowance of $500,000 has been included as the cost for managing the land acquisition process.



0 5
SCALE OF KILOMETRES

LEGEND

EXISTING LEVEES
LEVEE REALIGNMENT
FLOOD SURCHARGE STRUCTURE

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FIGURE 5.1 OPTION 2

jebllglm8

6.4 Benefits of Modified Findlay Scheme

6.4.1. Flood damage reduction

The Modified Findlay Scheme will lead to a reduction in average annual flood damage. This will arise from two principal causes: reduced flooding and reduced damages to the levees.

The reduction in flooding arises because:

- Approximately 137 km^2 of flood prone land (refer to **Figure 6.3**) would be acquired for the floodway. Virtually all this land is currently subject to flood overlay zoned for Rural Floodway or Land Subject to Inundation. Farming activities would cease and, in time, natural forests will be restored. It is considered that natural forest would not be subject to flood damage, even though it would be inundated more frequently. The total area of the floodway is 140.4 km^2 but it is estimated that approximately 2.5% of the total area is crown land (mainly the creeks) and therefor only 137 km^2 is privately owned and would need to be acquired;
- The levees forming the floodway would reduce the extent of flooding on the north bank. The Shepparton-Nathalia-Barmah sealed road would benefit significantly from reduced flooding;
- The standard of the existing levees downstream of the Deep Creek Outlet would be, in effect, "upgraded" because, for a given flood at Shepparton, a smaller proportion of the total flood flow would be confined to the main levee system;
- Relative to Option 2, more flood water enters the floodplain and this has environmental benefits in terms of reduced sediment and nutrient loads to the Murray River (although relative to existing conditions there is little change for major floods, but there is perceived benefits during the frequent floods that can not be readily be quantified).

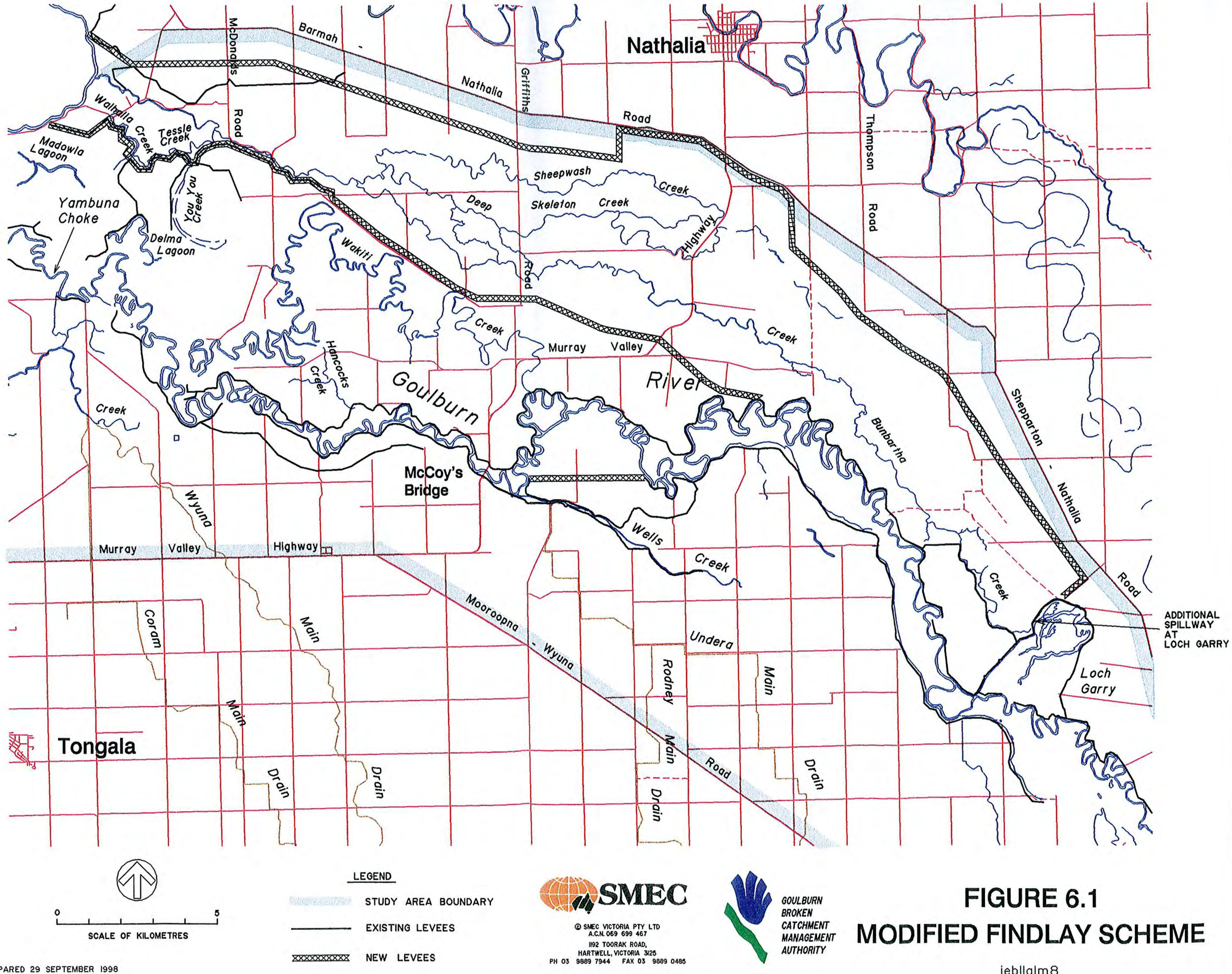

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FIGURE 6.1
MODIFIED FINDLAY SCHEME

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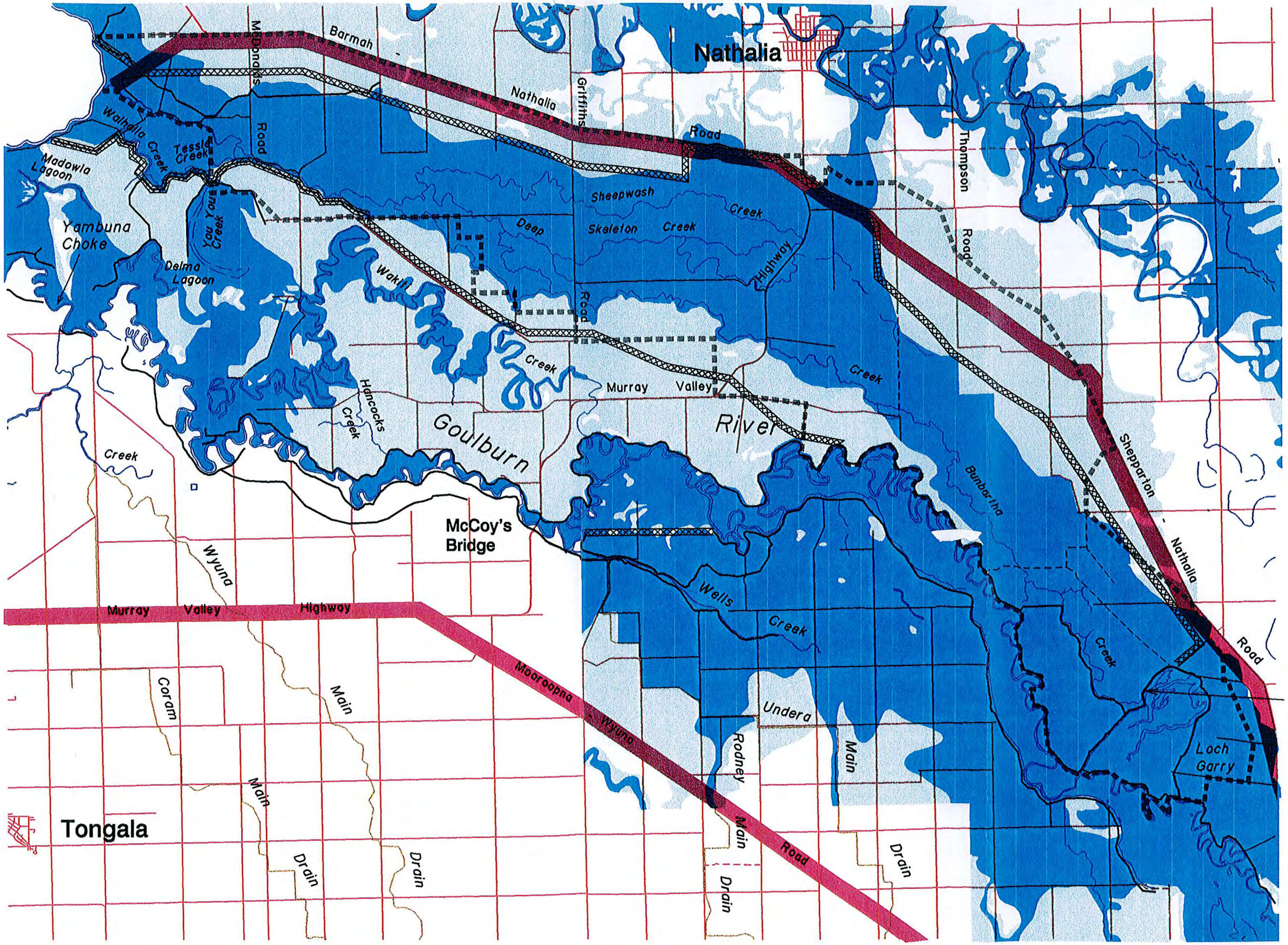

LEGEND

- STUDY AREA BOUNDARY
- LOCH GARRY FLOOD PROTECTION DISTRICT
- RURAL FLOODWAY AREA
- LAND SUBJECT TO INUNDATION AREA
- EXISTING LEVEES
- NEW LEVEES

0 5
SCALE OF KILOMETRES

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FIGURE 6.3
FLOOD OVERLAY

Table 6.1: Option 3 – Flood Prone Areas (ha)

It should be noted that the values in the table include flood prone land north of the Shepparton Barmah Road which is outside the nominated study area.

LAND USE	5 YEAR INUNDATION		ADDITIONAL 20 YEAR INUNDATION		ADDITIONAL 100 YEAR INUNDATION		TOTAL 100 YEAR INUNDATION	
	Option 3	Existing	Option 3	Existing	Option 3	Existing	Option 3	Existing
State Forest	5184	6400	932	1150	105	130	**6221**	**7680**
Private Forest	907	1120	1085	1340	130	160	**2122**	**2620**
Private non-irrigated	0	6400	1080	13220	4930	10670	**6010**	**30290**
Irrigation mixed	410	410	2474	3180	6699	7405	**9583**	**10995**
Dairy, Pigs, high capital	137	190	1368	1900	3802	5280	**5306**	**7370**
Horticulture	0	0	27	30	32	35	**59**	**65**
Special use	9	15	54	80	162	200	**225**	**295**
TOTAL	**6647**	**14535**	**7020**	**20900**	**15859**	**23880**	**29526**	**59315**

The costs and benefits of Option 3 are listed in **Table 7.2a** & **Table 7.2b**. The benefits are described in more detail in Appendix A.

Under Option 3, the Shepparton-Nathalia-Barmah Road and Murray Valley Highway (MVH) would benefit from a reduction of flooding frequency. Parts of the MVH located in the Deep Creek Floodway (approximately 3 km) would be inundated more frequently. In terms of flood damage this is more than offset by the reduced incidence of flooding of the remainder of the highway in the floodplain. The Shepparton-Nathalia-Barmah Road will benefit substantially under Option 3. Approximately 20 km of sealed road will cease to be flood prone. The adopted rate for repairing sealed road after prolonged inundation is $60,000 per kilometre.

6.4.2. Changes to Nutrient Loads and Perceived Water Quality Benefits

When floodwaters spread out onto a floodplain the flow velocities decrease and sediments are deposited. In general terms, nutrients such as Phosphorous are deposited and taken up by vegetation at a greater rate when the flow velocity is low. A reduction in the total phosphorous (TP) delivered to the Murray River would have benefits in terms of a reduction in the frequency of toxic algal blooms in the Murray River.

Under Option 3, more water enters the flood plain (principally the Deep Creek Floodway) than Option 2. This is deemed to be a benefit although both Options 2 and 3 reduce the amount of flood water entering the flood plain compared to existing conditions.

An attempt has been made to quantify the changes to the TP load delivered to the Murray River associated with Options 2 and 3 relative to Option 1. Results have been incorporated into the economic evaluation, however, given that the phosphorous concentration of flows in the Lower Goulburn River varies, water quality records are limited and the hydrological parameters are imprecise, the values should be regarded as approximate. The value, in terms of annual average dollars per tonne of changed TP loads has been determined by Read Sturgess and Associates in Reference 8. Details of the procedure for determining the values of nutrient changes are contained in Section 7.

The recent Murray Darling Basin Commission publication *Living on Floodplains* (Ref. 9) indicates that floodplains are essential for the well being of river health.

> *Floodplains not only supply food to rivers, they also seed rivers with living organisms, replenishing those washed downstream or eaten. Microoganisms on floodplains also remove potential pollutants from water, maintaining the natural chemical balance of rivers. Such feeding and cleaning services go unnoticed in healthy rivers, but when they are turned off the results may be disastrous.*
>
> *River stripped of their natural clean-up mechanisms become breeding grounds for undesirable organisms, large and small, and their water become contaminated with pollutants. Waterborne human and animal diseases flourish in a changed aquatic environment, while problems normally kept in check by natural biological controls burgeon out of control.*

The Modified Findlay Scheme is perceived to have two major benefits in terms of improving water quality. The first is due to expelling excess floodwater on a more frequent basis, (approximately on an annual basis) on to the adjoining floodplains. Floodwater across the floodplains will be stripped of its suspended sediment and nutrient material as its flow velocity reduces. In the long term as the floodplains become more vegetated, they will become more efficient sediment and nutrient strippers, which will provide benefit to the floodplain.

The greatest benefit derived by sediment and nutrient stripping is for the frequent flood events where significant amount of floodwaters escapes onto the adjoining floodplains compared to the current conditions where flows would be contained in the river-leveed system.

The second benefit is that there would be the inherent improvement of water quality in the Goulburn River entering the Murray River.

Quantification of these benefits is difficult however, for the purposes of this report, an attempt is made in section 8.4.

6.4.3. Biodiversity Benefits

The lower Goulburn River and its associated floodplain is a highly modified system, with a long history of human disturbance and modification. Despite this, the wider area of lower Goulburn remains one of the most environmentally important regions in Victoria, containing areas of habitat that are of State and National Significance. The forested floodplain of the Goulburn River is recognised as a critical 'biolink zone' providing a continuous inter-bioregional linkage between the forested foothills and highlands of the Great Dividing Range to the south and the Murray River to the north. The area also provides critical habitat for a range of threatened species and contains a number of examples of vegetation types that are depleted throughout the catchment.

The proposal to remove Lock Garry and some associated strategic levees to allow the northern and parts of the southern floodplains to function to a more natural flooding regime is likely to result in a substantial net gain for biodiversity conservation in the Goulburn Broken catchment. The 'multi-use' management of the MFS floodplain areas has the potential to provide a wide range of direct and indirect benefits to the wider community including:

- Restoration of more natural flows to the lower Goulburn River;
- Restoration of more natural flow regimes to the floodplains;
- Protection of significant, depleted vegetation types, threatened and declining species habitats;
- Changes to management of floodplain ecosystems and other areas of public land in the lower Goulburn area;
- The integration of significant areas of biodiversity; and
- Increased cover of native vegetation.

These benefits are discussed in detail in Appendix B.

6.4.4. Additional Flood Oufall for Broken Creek

A potential benefit associated with Option 3 is that it creates an opportunity for excess floodwaters in the Broken Creek to be diverted to the Deep Creek Floodway (DCF) via Skeleton Creek. A possible alignment for such a connecting floodway would be from the meander loop approximately 2 km east of the Murray Valley Highway directly west to the DCF. The floodway would be formed by bunds on acquired land. Refer to **Figure 6.1** and **Figure 6.3.**

Depending on the levels, it may be necessary to install gates at the confluence with the DCF to prevent flood waters in the DCF flooding back into Broken Creek during Goulburn floods. No computations and no allowances have been made for this possibility.

6.4.5. Dis-benefits of Option 3

There are several potential dis-benefits of the Modified Findlay Scheme and details of these are contained in Appendix B. These are briefly listed below:

- Unless carefully managed social disruption will be associated with land acquisition;
- Environmental effects during the construction phase;
- Environmental effects of miss-management of the Deep Creek Floodway such as allowing intensive grazing;
- The increase in native vegetation will increase the risk of bush fires; and
- Most of the benefits associated with Option 3 arise over time and are not tangible (flood damage reduction, enhanced environmental values, etc). This will make it difficult to obtain backing for the expenditure which, at approximately $10 million excluding land acquisition, is significant.

Most of these potential dis-benefits could, with careful management, be alleviated.

7. ECONOMIC EVALUATION OF OPTIONS

7.1 Economic Considerations

Options need to be evaluated on the basis of their likely economic performance. This is usually done relative to a "do nothing" Option, i.e. existing conditions. It should be noted that the economic costs and benefits due to the existing levees, relative to "natural conditions" (i.e. to those before the levees were constructed in 1898) are no longer a valid input to the decision making process for future management options.

The economic evaluation of Options is generally based on:
- the capital costs of the works required for implementing;
- the cost of on-going operation and maintenance;
- the benefits that arise from reduced flood damage to the levees, farm production, infrastructure;
- the changes in future production arising from land use changes
- residual values of assets constructed, but not the existing assets;
- changes to the sediment and nutrient load delivered to the Murray River; and
- non-measurable or intangible benefits such as enhanced environmental values.

Options 1 and 2 have been evaluated in reference 1. Most of the costs and benefits contained in those evaluations have been adopted. However, for options to be evaluated on a comparable basis, some costs and benefits have been re-evaluated or added to those in reference 1. These are:
- annual average flood damage reduction (re-evaluated); and
- changes to the sediment and nutrient loads delivered to the Murray River (explained below)

An economic evaluation of Options 1, 2 and 3 has been undertaken at a feasibility level of detail. The objective is to determine whether Option 3 is viable in comparison to Option 2.

The economic evaluation has been undertaken with assistance from Read Sturgess and Associates (RSA). Their report is included as Appendix A.

A discount rate of 4% has been used in the net present value calculations, this being the government requirement for economic evaluations. A rate of 8% has been used to check the sensitivity of the discount rate.

7.2 Flood Damage Reduction

The determination of flood damage reduction, for the purposes of this report, has been based on the changes to flooding frequency for land in the floodplain on a land use basis.

The values are presented in Table 7.1.

Table 7.1 Reduction in flood prone area susceptible to flood damage (ha) due to Options 2 and 3 relative to existing conditions (for use in damage assessment).

It should be noted that the values in the table include flood prone land north of the Shepparton Barmah Road which is outside the nominated study area.

LAND USE	5 YEAR		20 YEAR		100 YEAR		Totals	
	Option 2	Option 3	Option 2	Option 3	Option 2	Option 3	**Option 2**	**Option 3**
State Forest	640	1,216	115	219	13	25	**768**	**1,459**
Private Forest	112	213	134	255	16	30	**262**	**498**
Private non-irrigated	1280	6,400	2432	12,140	771	5,740	**4483**	**24,280**
Irrigation mixed	82	0	566	706	739	706	**1387**	**1,412**
Dairy, Pigs, high capital	38	53	380	532	1056	1,478	**1474**	**2,064**
Horticulture	0	0	0	3	0	4	**0**	**7**
Special use	5	6	20	26	20	38	**45**	**70**
TOTAL	**2157**	**7888**	**3647**	**13880**	**2615**	**8021**	**8419**	**29789**

The difference between options 2 and 3 in terms of total flood prone land is 21,379 ha (29,789 – 8419). Much of this difference is attributable to the assumption that under Option 3 the Deep Creek Floodway would no longer incur flood damages and land north of the Shepparton Barmah Road would be protected from flooding. The remaining quantity arises from the improved standard of the levees that arises from diverting more flood flow to the northern flood plain.

An important set of assumptions in the analysis is how to treat the changed land use of the Deep Creek Floodway. The land use will change from predominantly dry land agriculture to flood prone forests and wetland. It is therefore assumed that:

- Agricultural production from the area will drop from its current value to zero;
- Annual average flood damages will be effectively zero, (there will be some damage to roads) so this land area has been subtracted from the land subject to flooding matrix;
- Under the future land use regime (camping, nature retreats) the area might be at least as valuable as at present (RSA p25).

7.3 Future Farm Production Forgone

A rigorous analysis of the productive capacity of the agricultural land in the Deep Creek Floodway has not been undertaken. For the purposes of this economic evaluation however, annual agricultural production has been assumed to be related to market value. It was assumed that on average, the annual return from the property would be 5% of the property value (assumed for the purposes of this report to be approximately $750 per ha.

7.4 Water Quality

The determination of changes to the quality of water delivered to the Murray River, principally nutrients such as phosphorus and the suspended sediment load, is not an exact science. An analysis needs to assess variables such as, floodplain hydrology, water quality at Shepparton, the deposition of sediments and take up of nutrients in the floodplain.

An assessment of the changes to nutrient loads was undertaken and was based on the following assumptions.

- In terms of the volume of water entering the floodplain

- In a 5-year ARI flood, here would be little difference between Options 1 and 2, but Option 3 delivers more water to the floodplain at Loch Garry,
- In 20-year and 100-year ARI floods, Options 2 confines more water to the river channel than Option 1 due to a smaller incidence of levee failure;
- IN 20-year and 100-year ARI floods, Option 3 confines more water to the river channel than Option 1 due to the effective raising of levee standard, but compared to Option 2, more water flows into the floodplain at Loch Garry;

- Reduction of total phosphorous (TP) occurs only when water enters the floodplain;
- The average concentration of TP of flood water entering the floodplain is 0.018 mg/l
- There is a 25% reduction of TP when water flows down the floodplain due to the slower flow velocities relative to flows in the main channel.

The results of this investigation are presented in **Table 7.2**

Table 7.2. Water Quality Analysis

ARI (years)	AEP (%)	Volume in floodplain (ML x 10^3)	Incremental Volume in Floodplain (ML x 10^3)	Accumulated Annual Volume in Floodplain (ML x 10^3)
Option 1				
2	0.5	0.00	0.00	0.00
5	0.2	0.00	0.00	0.00
20	0.05	432.00	32.40	32.40
100	0.01	600.00	20.64	53.04
Option 2				
2	0.5	0.00	0.00	0.00
5	0.2	0.00	0.00	0.00
20	0.05	186.00	13.95	13.95
100	0.01	311.00	9.94	23.89
Option 3				
2	0.5	15.00	0.00	0.00
5	0.2	65.00	12.00	12.00
20	0.05	281.00	25.95	37.95
100	0.01	368.00	12.98	50.93

7.5 Environmental and Other Benefits From New Land Use

Under Option 3, land in the Deep Creek Floodway would be acquired and, with time would return to natural Red Gum forest. RSA (refer to Appendix A) have undertaken an assessment and valuation of the benefits associated with this change in land use. These are:

- Increased habitat for squirrel glider, brush-tailed Phascogale, large-footed Myotis (RSA p 21). RSA suggest a net present value of $3 million could apply based on the theoretical willingness of households in the Goulburn Catchment (30,000 households) to pay $5/year for 30 years for the increased habitat for these species. This value is somewhat theoretical and a value of $200,000 has been adopted as an appropriate value for the "most probable" evaluation;

- Protection of the habitat for platypus and native fish. RSA have suggested a value of approximately $0.2 million may be appropriate. This is somewhat theoretical and a value of $100,000 was adopted for the "most likely" evaluation;
- Increased value of wetlands (RSA p 20), no dollar value adopted for evaluation purposes.

It has been suggested that changing much of the land use in the Deep Creek Floodway from agriculture to forests will have a benefit in terms of greenhouse gas reduction. This is probably true but this benefit has not been explicitly allowed for in this evaluation because it is considered too difficult to define the value in monetary terms. Furthermore, other biodiversity benefits describe in Appendix B have also not been explicitly allowed for the same reason.

7.6 Benefit Cost Ratios

A cost benefit analysis of Options 2 and 3 has been carried out, refer to **Table 7.3a** and **Table 7.3b**.

Several of the inputs to this analysis are based on assumptions that are debatable, such as the environmental benefits. For this reason two sets of values have been used, a "most probable" and a "conservative" set. Key assumptions and values adopted for the "most probable" case include:

- Costs to upgrade levees are the same for Options 2 and 3;
- The annual farm production forgone is equal to the annual "lease back" value of the land (this is considered to conservative);
- Increased habitat for the squirrel glider, etc and protection of habitat for fish and platypuses is worth $1.2 million.

For the "conservative" analysis, the following changes were made:

- Capital cost of Deep Creek Floodplain levees up from $7 million to $8million;
- Benefit due to annual average flood damage reduction down 25% from $1.32 million to $0.99 million;
- No relative benefit from Option 3 due to reduced nutrient loads to the Murray River.
- Annual "lease back" value of the land down from $440,000 to $220,000;
- Zero benefit assumed for increased and protected habitat.

Results of the benefit cost analysis are presented in **Table 7.4**. Based on the benefit cost analysis, Option 3 is clearly a better option than Option 2, even if the "conservative" assumptions are used.

Table 7.4 Results of benefit cost analysis

Item	Description	B/C ration Option 2	B/C ratio Option 3
1	Most probable set of assumptions	0.74	1.96
2	Conservative set of assumptions	0.95	1.32

Table 7.3a Economic Evaluation of Options (most probable assumptions)

Item	Description	Option 1	Option 2	Mod Findlay
1	**Initial Capital Costs**			
1.1	Levee realignment (p 77)		$1,510,000	
1.2	Land acquisition (mangement fee)			$500,000
1.3	Upgrade levee		$1,310,000	$1,310,000
1.4	Drainage outfall structure improvements		$385,000	
1.5	Flood surcharge structure improvements		$2,330,000	$300,000
1.7	Development of floodways		$120,000	
1.8	Deep Creek Floodway Levees			$7,000,000
1.9	Loch Garry gate replacement		$1,200,000	
1.10	Deep Creek outlet reinstatement/modification	$3,500	$20,000	
1.11	Monitoring equipment	$32,000	$39,000	$39,000
1.12	Removal of levees at Keoghs	$10,000	$0	
1.13	Spillway at Loch Garry			$300,000
	Sub-total	**$45,500**	**$6,914,000**	**$9,449,000**
2	**Waterway Management Costs (1)**			
2.1	NPV of Lower Goulburn waterway management: levee realignment away from river.	$4,110,000	$4,110,000	$3,700,000
2.2	NPV of Deep Creek Floodway waterway management: monitoring and stabilising any erosion sites that develop.	$0	$0	$411,000
	Sub-total	**$4,110,000**	**$4,110,000**	**$4,111,000**
3	**Annual (on-going) costs**			
3.1	Annual maintenance cost	$180,000	$105,000	$120,000
3.2	Annual average levee repair costs	$74,000	$25,000	$50,000
3.3	Annual monitoring cost	$22,000	$22,000	$22,000
3.4	Increase in annual average nutrient load (compared to existing)	$0	$160,000	$20,000
3.5	Farm production foregone on land acquired for floodways	$0	$75,000	$440,000
	Sub-total	**$276,000**	**$387,000**	**$652,000**
4	**Benefits (annual average)**			
4.1	Flood damage reduction to agricultural lands	$0	$440,000	$1,570,000
4.2	Flood damage reduction to the levees (annual average relative to existing	$0	$53,000	$10,000
4.3	Land use change to forests, camping, nature retreats			$440,000
	Sub-total	**$0**	**$493,000**	**$2,020,000**
5	**Bennefits (NPV)**			
5.1	Increased value of wetlands (RSA p 20)			$0
5.2	Increased habitat for squirrel glider, brush-tailed Phascogale, large-footed Myotis (RSA			$200,000
5.3	Protection of habitat for platypus and native fish			$100,000
	Sub-total	**$0**	**$0**	**$300,000**
6	**Residual values (end of project life)**			
6.1	Earthwork assets	$0		
6.2	Structural assets	$0		
	Sub-total	**$0**	**$0**	**$0**
	Benefit -cost ratios		**0.74**	**1.96**

1. Warerway Management Costs and Benefits have not been included in the BCR's because under Options 2 and 3 they are considered to be equivalent.

"Min most approach compared with the original solution"

Table 7.3a Economic Evaluation of Options (most probable assumptions)

Economic Evaluation of Options

Project life = 100 years
Discount Rate = 4%

Description	Option 2	Option 3
NPV Capital costs ($1000)	($6,914,000)	($9,449,000)
Annual maintenance, lost farm production, costs	($387,000)	($652,000)
NPV of annual maintenance, lost production, etc, costs	($9,483,435)	($15,977,259)
NPV of total costs	**($16,397,435)**	**($25,426,259)**
Benfits determined as a present value	$0	$300,000
Annual average benefits	$493,000	$2,020,000
NPV recurrent benefits	$12,080,965	$49,500,098
Residual value of assets at end of project life	$0	$0
NPV of residual value of assets	$0.00	$0.00
NPV of total benefits	**$12,080,965**	**$49,800,098**
Benefit cost ratio	0.74	1.96

Table 7.3b Economic Evaluation of Options (conservative assumptions)				
Item	**Description**	**Option 1**	**Option 2**	**Mod Findlay**
1	**Initial Capital Costs**			
1.1	Levee realignment (p 77)		$1,510,000	$300,000
1.2	Land acquisition			$500,000
1.3	Upgrade levee		$1,310,000	$1,310,000
1.4	Drainage outfall structure improvements		$385,000	
1.5	Flood surcharge structure improvements		$2,330,000	$300,000
1.7	Development of floodways		$120,000	
1.8	Deep Creek Floodway Levees			$8,000,000
1.9	Loch Garry gate replacement		$1,200,000	
1.10	Deep Creek outlet reinstatement/modifica	$3,500	$20,000	
1.11	Monitoring equipment	$32,000	$39,000	$39,000
1.12	Removal of levees at Keoghs	$10,000	$0	
1.13	Spillway at Loch Garry			$300,000
	Sub-total	**$45,500**	**$6,914,000**	**$10,749,000**
2	**Waterway Management Costs ***			
2.1	NPV of Lower Goulburn waterway management: levee realignment away from river.	$4,110,000	$4,110,000	$3,700,000
2.2	NPV of Deep Creek Floodway waterway management: monitoring and stabilising any erosion sites that develop.	$0	$0	$411,000
	Sub-total	**$4,110,000**	**$4,110,000**	**$4,111,000**
3	**Annual (on-going) costs**			
3.1	Annual maintenance cost	$180,000	$105,000	$120,000
3.2	Annual average levee repair costs	$74,000	$25,000	$50,000
3.3	Annual monitoring cost	$22,000	$22,000	$22,000
3.4	Increase in annual average nutrient load (compared to existing)	$0	$0	$0
3.5	Farm production foregone on land acquired for floodways	$0	$75,000	$440,000
	Sub-total	**$276,000**	**$227,000**	**$632,000**
4	**Benefits (annual average)**			
4.1	Flood damage reduction to agricultural	$0	$430,000	$1,178,000
4.2	Flood damage reduction to the levees (annual average relative to existing	$0	$53,000	$10,000
4.3	Land use change to forests, camping, nature retreats			$220,000
	Sub-total	**$0**	**$483,000**	**$1,408,000**
5	**Bennefits (NPV)**			
5.1	Increased value of 500 ha of wetlands @			$0
5.2	Increased habitat for squirrel glider, brush tailed Phascogale, large-footed Myotis			$0
5.3	Protection of habitat for platypus and native fish			$0
	Sub-total	**$0**	**$0**	**$0**
6	**Residual values (end of project life)**			
6.1	Earthwork assets	$0		
6.2	Structural assets	$0		
	Sub-total	**$0**	**$0**	**$0**
	Benefit -cost ratios		0.95	1.32

* Warerway Management Costs and Benefits have not been included in the BCR's because under Options 2 and 3 they are considered to be equivalent.

Table 7.3b Economic Evaluation of Options (conservative assumptions)

Economic Evaluation of Options

Project life = 100 years
Discount Rate = 4%

Description	Option 2	Option 3
NPV Capital costs ($1000)	($6,914,000)	($10,749,000)
Annual maintenance, lost farm production, costs	($227,000)	($632,000)
NPV of annual maintenance, lost production, etc, costs	($5,562,635)	($15,487,159)
NPV of total costs	**($12,476,635)**	**($26,236,159)**
Benfits determined as a present value	$0	$0
Annual average benefits	$483,000	$1,408,000
NPV recurrent benefits	$11,835,915	$34,503,039
Residual value of assets at end of project life	$0	$0
NPV of residual value of assets	$0.00	$0.00
NPV of total benefits	**$11,835,915**	**$34,503,039**
Benefit cost ratio	0.95	1.32

8. CONCLUSIONS

Based on the benefit cost analysis undertaken, which excludes the environmental benefits that arise from the waterway management program, Option 3 is clearly more economically viable than Option 2.

Should Option 3 proceed, the potential dis-benefits, especially the social disruption associated with the land acquisition, should be managed with care.

9. REFERENCES

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3. Lewis R: "Extract from a paper on the Loch Garry Flood Protection Scheme presented to the Institution of Engineers Australia", 1927

4. DNRE Floodplain Management Section: "McCoys Bridge Distribution of Flood Flows, Revised August 1995

5. Rural Water Commission: "Lower Goulburn Floodplain Management Study, Shepparton to Kanyapella, Main Report and Technical Report 1987". [Cameron McNamara]

6. DNRE Floodplain Management Section: "Moira Shire and City of Greater Shepparton Flood Mapping", 1997 (adopted as planning overlays within the respective new proposed planning schemes).

7. Goulburn Broken Catchment Management Authority: "Goulburn Broken Water Quality Strategy, Benefits from Reducing Frequency of Algal Blooms in the Goulburn Broken Catchment, January 1998" [Read Sturgess and Associates with Rendell McGukian]

8. The Nathalia Herald: "The Goulburn River Levees, How they Originated, May 5 1936 [George Stickles].

9. DCNR Floodplain Management Section: "Documentation and Review of 1993 Victorian Floods, Lower Goulburn River Flood October 1993 Vol 5" [HydroTechnology, March 1995]

10. Thiess Environmental Services: "Goulburn River @ Shepparton, Rating Table" Effective from February 1998.

11. MDBC "The Murray", Canberra 1990.

12. The Parliamentary Public Works Committee: "The Goulburn River Floodway Inquiry" 1963.

APPENDIX A:

Economic Assessment by Read Sturgess and Associates

APPENDIX BENEFITS OF FLOODPLAIN MANAGEMENT OPTIONS

SUMMARY

We have considered three types of impacts:

1. avoidance of flood damage
2. reduced nutrient loads
3. improved environmental values

AVOIDANCE OF FLOOD DAMAGE

Options 2 and 3 would reduce the areas of inundation and are also likely to reduce the duration of inundation from an average of two to three weeks back to five to seven days. We have calculated the benefits with and without attributing a benefit to the reduced duration. The critical length of duration before plant death occurs is uncertain, but it is generally around 4 days for clovers and 7 days for grasses.

NPV and annual expected value of the flood damage benefits from the two options, assumes no change in duration.

	Present Value 4% discount (million)	Present value 8% discount (million)	Expected Annual Value (million)
Option 2	$10.86	$5.53	$0.44
Option 3	$38.48	$19.62	$1.57

NPV and annual expected value of the flood damage benefits from the two options given a reduction in damages per hectare.

	Present Value 4% discount (million)	Present value 8% discount (million)	Expected Annual Value (million)
Option 2	$22.27	$11.36	$0.91
Option 3	$43.48	$22.17	$1.77

REDUCED NUTRIENT LOADS

Sediment being dropped on the floodplain during floods would represent the removal of TP from the waterbodies and waterways. Both Options 2 and 3 would reduce the amount of TP being dropped on the floodplain during floods and, as such, nutrient loads in the lower Goulburn River and River Murray would be increased. The implied expected value of costs for each option would be:

	Low estimate	High estimate
Option 2	$0.08	$0.16 million per year
Option 3	$0.01	$0.02 million per year

MPROVED ENVIRONMENTAL VALUES

The floodplain of the Lower Goulburn River is a valuable environmental asset. Option 3 has the potential to enhance this value by increasing the area which could have a more natural and diverse environment and, possibly, by reducing damages on the main river. This, in turn, could affect the populations of important native flora and fauna. There is also the opportunity to enhance a variety of recreational opportunities.

Local evidence and evidence from overseas suggests that both the non-use values and use values which could be influenced by Option 3 have significant unit values. The overall benefit would depend on the numbers of people affected and the amount of environmental improvement.

CONTENTS

1. AVOIDANCE OF FLOOD DAMAGE

1.1 EXPECTED DAMAGES UNDER PRESENT FLOODPLAIN MANAGEMENT

An assessment of land use under present floodplain management has been based on information provided by SMEC, supplemented by visual inspection of the area, and details are presented in Table 1-1. Most of the flooded areas are used for, non-irrigated agriculture, irrigated agriculture and forestry.

1.1.1 Damages to agricultural enterprises

The level of damages to crops and pastures would depend on the time of year the flooding occurred as well as the duration, velocity and depth of flooding. It is assumed that the flooding would occur between January and October. Conceivably livestock losses could be incurred; however, it is more likely that graziers would have sufficient notice to remove their stock, and we have not included any losses of livestock for the three flood events. It is expected that the duration of flooding would be two to three weeks at an average depth of 0.2 to 0.5 meters.

Damages due to flooding can be calculated on a land-use basis or on a farm level basis. SMEC has provided estimates of the areas inundated by landuse (see Table 1-1), and therefore impacts have been calculated on this basis. Floods impact on the total farming enterprises and, consequently, total farming enterprise costs have also been included.

Table 1-1: **Total land by use and areas inundated given a 1 in 5, 20 and 100 year flood event.**

	Total Land Use hectare	Area Inundated ARI 5 year	Area Inundated ARI 20 year	Area Inundated ARI 100 year
State Forest	8,453	6,400	7,550	7,680
Private Forest	2,798	1,120	2,460	2,620
Private Non-Irrigated	31,116	6,400	19,620	30,290
Irrigation Mixed	13,250	410	3,590	10,995
Dairying, Pigs, High Capital	9,570	190	2,090	7,370
Horticulture	102	0	30	65
Special Use	310	15	95	295
Total	65,599	14,535	35,435	59,315
% inundated		22%	54%	90%

Based on information collected for studies of impacts from the 1993 floods, the following assumptions were made as to the typical structure of the different land classes provided (see Table 1-2).

Table 1-2: Structure of land-use classifications

		Irrigation		
	Non-Irrigated	Mixed	Dairy	Horticulture
Cropping	30%	30%	0%	0%
Permanent pastures	0%	0%	100%	0%
Annual pasture	70%	70%	0%	0%
Hoticulture	0%	0%	0%	100%
Total	100%	100%	100%	100%

1.1.1.1 Irrigated pastures

A distinction was made between irrigated perennial and irrigated annual pastures. While the magnitude of losses is different, the type of losses are similar on the two pasture types.

Following discussions with officers of DNRE, the consultants have concluded that of the paddocks that are inundated, on average one-third would be re-established, one-third would be over-sown, and the remaining third would remain untreated. The costs of re-sowing are $220 per hectare whereas the costs of over-sowing are $75 per hectare.

It has been estimated that inundation would impact on pasture production for three months. This time allows for the floods to recede, paddocks to dry, pastures to be topped, and if necessary raked, to remove dead material and to allow new grass to grow. This time also allows for any over-sowing to be completed and if required, fertilisers applied.

Growth rates were examined for various annual and perennial grass species to determine total losses in production. The calculation of flooding losses took into account the nature of the grazing enterprises, in particular, the intensity with which pastures were grazed, and the energy, protein and DMI requirements of the livestock who consumed the pasture.

Table 1-3

Cost of damage to irrigated permanent pastures and lucerne

	ARI 5	20	100
Basis for estimation			
Area flooded (ha)	190	2,090	7,370
Stocking Rate dse/ha	26	26	26
Percentage of livestock losses	0%	0%	0%
Value of livestock losses ($/dse)	$26.00	$26.00	$26.00
Cost of re-sowing pasture ($/ha)	$148	$148	$148
Proportion of pastures requiring re-sowing	66%	66%	66%
Loss in pasture production (utilised) for pastures requiring re-sowing (tonnes)	2.5	2.5	2.5
Loss in pasture production (utilised) for pastures not requiring re-sowing (tonnes)	0.85	0.85	0.85
Cost of Supplements ($/Tonne)	$180.00	$180.00	$180.00
Proportion of pastures requiring agistment	50%	50%	50%
Loss of income ($/ha)	$1,064.20	$1,064.20	$1,064.20
Total damage costs from each flood ($ million)			
Livestock losses	$0.00	$0.00	$0.00
Pasture re-sowing costs	$0.03	$0.31	$1.09
Value of production loss for pastures requiring re-sowing	$0.06	$0.62	$2.19
Value of production loss for pastures not requiring re-sowing	$0.01	$0.11	$0.38
Loss in value of milk	$0.10	$1.11	$3.92
Total ($ million)	$0.20	$2.15	$7.58

Table 1-4

Cost of damage to irrigated annual pastures

	ARI 5	20	100
Basis for estimation			
Area flooded (ha)	287	2,513	7,697
Stocking Rate dse/ha	13	13	13
Percentage of livestock losses	0%	0%	0%
Value of livestock losses ($/dse)	$25.00	$25.00	$25.00
Cost of re-sowing pasture ($/ha)	$123	$123	$123
Proportion of pastures requiring re-sowing	66%	66%	66%
Loss in pasture production (utilised) for pastures requiring re-sowing (ton	2.0	2.0	2.0
Loss in pasture production (utilised) for pastures not requiring re-sowing (	1.0	1.0	1.0
Cost of Supplements ($/Tonne)	$130.00	$130.00	$130.00
Total damage costs from each flood ($ million)			
Livestock losses	$0.00	$0.00	$0.00
Pasture re-sowing costs	$0.04	$0.31	$0.95
Value of production loss for pastures requiring re-sowing	$0.05	$0.43	$1.32
Value of production loss for pastures not requiring re-sowing	$0.01	$0.11	$0.34
Total ($ million)	$0.10	$0.85	$2.61

1.1.1.2 Dryland pastures

The flooding losses from dryland pastures refer to improved annual pastures.

Of the pasture species, subterranean clover will generate naturally in the following season, while the failure of annual ryegrass to set seed will impact on the future productivity of the pasture. It is judged that, on average, one third of dryland pastures would require re-establishing. Of this third, one third would be re-established while the remaining two-thirds would be over-sown at a cost of $75 per hectare.

The calculation of flooding losses considered the energy supplied from the proportion of these pastures utilised. Due to the nature of the livestock that graze dryland pasture, the quality of dietary supplement was less of an issue in comparison to irrigated pastures.

Table 1-5

Cost of damage to dryland pastures

	ARI		
	5	20	100
Basis for estimation			
Area flooded (ha)	4,480	13,734	21,203
Stocking Rate dse/ha	5	5	5
Percentage of livestock losses	0%	0%	0%
Value of livestock losses ($/dse)	$26.00	$26.00	$26.00
Cost of re-sowing pasture ($/ha)	$123	$123	$123
Proportion of pastures requiring re-sowing	33%	33%	33%
Loss in pasture production (utilised) for pastures requiring re-sowing (ton	1.5	1.5	1.5
Loss in pasture production (utilised) for pastures not requiring re-sowing (	0.75	0.75	0.75
Cost of Supplements ($/Tonne)	$130.00	$130.00	$130.00
Total damage costs from each flood ($ million)			
Livestock losses	$0.00	$0.00	$0.00
Pasture re-sowing costs	$0.55	$1.69	$2.62
Value of production loss for pastures requiring re-sowing	$0.29	$0.88	$1.36
Value of production loss for pastures not requiring re-sowing	$0.29	$0.90	$1.39
Total ($ million)	**$1.13**	**$3.47**	**$5.36**

1.1.1.3 Broadacre crops

In the case of broadacre crops (mainly cereals), it is likely that flooding will completely destroy crops. Crops would not be able to be re-sown due to the lateness of the season. In some cases, the crop would be continued, but it is assumed that the yield reduction would prevent the crop being harvested. It is more likely that crops would be used for fodder or alternatively cut for hay. It is the consultants opinion that the benefits from these options would do little to reduce the cost of the flood, which in this case is equal to the income foregone.

Consultation with DNRE staff provided estimates of likely crop yields from dryland and irrigated areas in the Lower Goulburn region. Yields of 3.0 T/ha and 2.5 T/ha were used for irrigated and dryland areas respectively.

Included in the study region is an irrigated mixed farm which grows considerable areas of rice. Given the time required for inundated areas to drain and dry, it has been assumed that a rice crop could still be established, but that a later variety would be sown.

Table 1-6

Cost of damage to irrigated broadacre crops

	ARI		
	5	20	100
Basis for estimation			
Area flooded (ha)	123	1,077	3,299
Foregone income less harvesting costs	$299	$299	$299
Total damage costs from each flood ($ million)	**$0.04**	**$0.32**	**$0.99**

Table 1-7

Cost of damage to dryland broadacre crops

	ARI		
	5	20	100
Basis for estimation			
Area flooded (ha)	1,920	5,886	9,087
Foregone income less harvesting costs	$238	$238	$238
Total damage costs from each flood ($ million)	**$0.46**	**$1.40**	**$2.16**

1.1.1.4 Horticultural crops

There is only a small area of peaches grown in the study area. Due to the location of the horticultural block on the edge of the inundated area, it is likely that the duration of flooding would be less than one week. Peaches are particularly sensitive to flooding and therefore even a flood of this duration is likely that the majority of tree crops could be killed by such flood events and require replacement.

For those tree crops that are not killed, there would probably be a total loss of production in the year of flooding owing to the likelihood of disease following the flooding. Further, flooding restricts farmers from accessing their orchards to spray them and hence there is an increased incidence of pests and diseases over the following Summer which results in drastic reductions in yields for surviving trees. Some crop losses due to conditions such as Mildew and Phytophera would occur directly due the wetting/humidity, and this would be exacerbated by the likelihood that orchardists would not be able to continue their usual spray programmes due to lack of access to flooded crops.

We have estimated the damages based on a need to replace 55% per cent of crops and a total loss of production for one year for the surviving crops.

The loss of production in the year of flooding is measured as the gross value of the crop less harvesting costs, but the loss of production in subsequent years would be measured as the gross margin since variable costs would be occurred during the period while waiting for new tree crops to come into commercial production.

Table 1-8

Cost of damage to irrigated horticultural enterprises

	ARI 5	20	100
Basis for estimation			
Area flooded (ha)	0	30	65
Crop yield (T/ha)	30	30	30
Crop value ($/T)	$400	$400	$400
Variable costs of production ($/T)	$200	$200	$200
Re-establishment cost per ha	$14,000	$14,000	$14,000
Percentage trees killed	55%	55%	55%
Period of production lost for trees needing replacement (years)	3	3	3
Period of production lost for trees not needing replacement (years)	1	1	1
Total damage costs from each flood ($ million)			
Value of production loss for crop needing replacement	$0.00	$0.40	$0.86
Value of production loss for crop not needing replacement	$0.00	$0.16	$0.35
Crop re-establishment costs	$0.00	$0.23	$0.50
Total ($ million)	**$0.00**	**$0.79**	**$1.71**

1.1.1.5 Farm assets

Damage to farm equipment and access tracks are estimated at $3000 per property, based on the estimated average losses during the 1993 flood (Department of Conservation and Natural Resources 1993).

Table 1-9

Cost of damage to urban and farm buildings

	ARI 5	20	100
Basis for estimation			
Number of farms	100	200	240
Proportion of cases involving damage above floor level (%)	0%	0%	0%
Proportion of cases involving damage not above floor level (%)	100%	100%	100%
Damage per house flooded above floor level ($)	$12,700	$12,700	$12,700
Damage per house flooded to less than floor level ($)	$3,000	$3,000	$3,000
Number of urban properties	0	0	0
Total damage costs from each flood ($ million)			
Damage to buildings in urban areas	$0.00	$0.00	$0.00
Damage to buildings on farms	$0.30	$0.60	$0.72
Total ($ million)	**$0.30**	**$0.60**	**$0.72**

1.1.1.6 Loss in Income/Personal hardship

Losses in off-farm income have been valued at five days at $100 a day. Due to their very nature, losses in income can not be easily converted to costs per hectare. The following number of farms have been assumed to be inundated for a the flood events shown in Table 1-10.

Table 1-10 Number of Farms inundated during 5, 20 and 100 year flood events.

	ARI 5 Years	ARI 20 Years	ARI 100 Years
Number of Farms Affected	100	200	240

Table 1-11

Loss in income and personal expenses

	ARI		
	5	20	100
Basis for estimation			
Number of farms	100	200	240
Absence from employment (weeks)	1	1	1
Weekly income	$500	$500	$500
Other personal expenses	$0	$0	$0
Total damage costs from each flood ($ million)	**$0.05**	**$0.10**	**$0.12**

1.1.1.7 Livestock

The relevant grazing enterprises in the Lower Goulburn area include wool and lamb enterprises, various beef fattening enterprises, dairy cattle and some alternative enterprises including venison and emus. Based on evidence from the 1993 flood in the area, it was assumed that most livestock could remain within a short distance from the affected flood land either on higher ground or agisted on neighbouring properties. The only costs incurred would be those required to cart or move stock around the property.

The situation with dairy cattle is a little different. During the likely months of a flood (September to November), a dairy cow is in peak lactation. Research shows that production throughout the remainder of the lactation cycle is dependent on production during these months. It is therefore important that cattle are not stressed or under-fed during this period.

The consultants assumed that 50% of dairy farms would totally relocate their herds to other farms and totally forego any income they produce during this period. It is assumed that the income earned would offset agistment costs on the host dairy farm.

No livestock losses have been included in the analysis. In the study region, sufficient warning should be given to farmers to relocate livestock and therefore losses will be negligible. In the 1993 flood, only $30,000 was included for stock loss, which comprised only 0.2% of the total agricultural losses calculated.

1.1.1.8 Special Use

Areas classified as special use are predominantly areas used for equestrian activities. No cost has been included for these areas.

1.1.2 Damages to forestry enterprises

The only commercial cutters likely to be affected during a flood event are sleeper cutters. Saw log operations and firewood are cut during alternative times of the year. It has been estimated that, in the event of a flood, two months of access will be prevented. Access to forests is effected in non-flood years, therefore only one month of the two month loss in access is assumed to be attributable to the flood.

The area of the Lower Goulburn that is logged is relatively small. Only approximately 1300 sleepers were cut in 1997.

Table 1-12

Cost of damage to public forests

	ARI		
	5	20	100
Basis for estimation			
Number of sleepers cut /month	128	128	128
Months of production effected	1	1	1
Value of production ($/sleeper)	$20	$20	$20
Variable costs ($/sleeper)	$1	$1	$1
Total damage costs from each flood ($ million)	**$0.002**	**$0.002**	**$0.002**

1.1.3 Damages to roads

SMEC have estimated that the cost to repair unsealed and sealed roads in the flooded areas are $10 and $60 thousand respectively. In other words, all roads within the inundated area will experience damage and require repair.

Table 1-13

Cost of damage to roads

	ARI		
	5	20	100
Basis for estimation			
Area flooded km			
Unsealed roads	145	326	539
Sealed Roads	1	17	31
Cost to repair unsealed roads (per km)	$10,000	$10,000	$10,000
Cost to repair sealed roads (per km)	$60,000	$60,000	$60,000
Cost to repair channels and drains	$148,100	$425,000	$726,300
Total damage costs from each flood ($ million)	**$1.63**	**$4.68**	**$7.99**

1.1.4 Total damages under existing floodplain management

The estimates of total damage costs for the three flood events are summarised in Table 1-14.

Table 1-14

Total cost of damages ($ million) existing floodplain management

	ARI 5	20	100
Cost of damage to irrigated permanent pastures and lucerne	$0.2	$2.1	$7.6
Cost of damage to irrigated annual pastures	$0.1	$0.9	$2.6
Cost of damage to dryland pastures	$1.1	$3.5	$5.4
Cost of damage to irrigated broadacre crops	$0.0	$0.3	$1.0
Cost of damage to dryland broadacre crops	$0.5	$1.4	$2.2
Cost of damage to irrigated horticultural enterprises	$0.0	$0.8	$1.7
TOTAL COST TO AGRICULTURAL ENTERPRISES	$1.9	$9.0	$20.4
TOTAL COST TO PUBLIC LANDS	$0.0	$0.0	$0.0
TOTAL COST OF PERSONAL EXPENSES	$0.1	$0.1	$0.1
TOTAL COST TO STRUCTURES & EQUIPMENT	$0.3	$0.6	$0.7
TOTAL COST TO ROADS	$1.6	$4.7	$8.0
TOTAL	$3.9	$14.4	$29.2

These represent the total damages resulting from one occurrence of each flood event; namely:

5 year flood	$3.9	Million
20 year flood	$14.4	Million
100 year flood	$29.2	Million

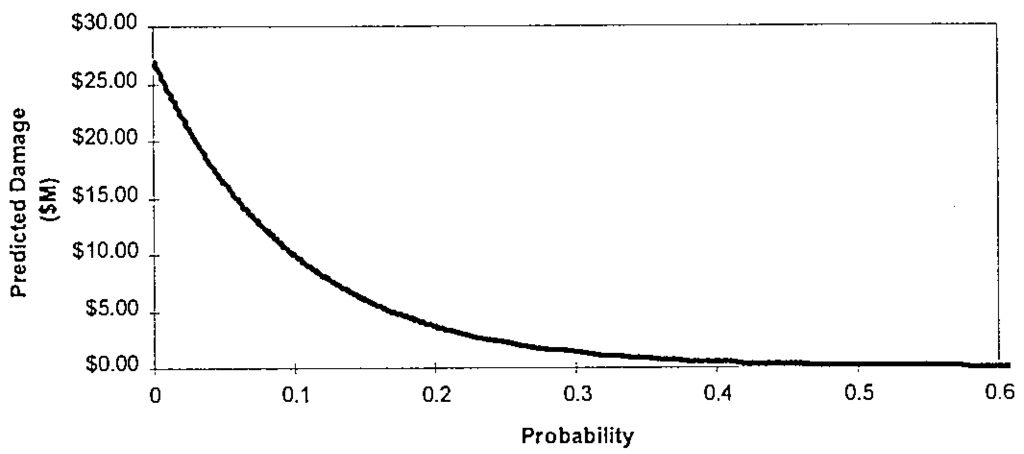
To allow comparisons of the costs of engineering works to provide protection against flooding, it is necessary to estimate the *expected annual value* of damages from flooding in the future without the works. This is achieved by fitting a curve to the three estimated points and integrating to estimate the area under that curve (see Figure 1). The Adjusted R-Square for the fitted curve is 95.7%. This suggests that there is a good fit between the curve and the estimated damages.

During 1995, an estimation of damages in the 1993 flood in the Lower Goulburn was completed by HydroTechnology in consultation with the then Department of Conservation and Natural Resources. HydroTechnology estimated total damages for the 30 year flood event at $23.59 Million. The estimation of flooding damages for a 30 year flood event in this consultancy is only $19.44 million. The reasons for the differences can in part be attributed to the methodologies used by the two studies.

In addition, the consultants feel that the assumption made in the earlier estimate that 50% of the farms affected in the study area were dairy farm appears high. Estimates of land-use provided by Cameron McNamara (1987) suggest that the proportion of dairy farms is much less than this.

The area so estimated represents the *expected value* of flooding in any one year and this should then be divided by the chosen discount rate in order to prove an estimate of the present value of the expected value of damages from flooding in the future without the works.

Fig 1 Average annual damage curve



We have estimated that the *expected value* of flooding in any one year is about $2.80 million (measured as the area under the curve in Figure 1), which over 100 years suggests the following present value of damages in the future:

4% discount $68.70 million

8% discount $35.03 million

1.2 Damages under option 2

Given option 2, the areas inundated are reduced by the areas shown in Table 1-15. Note these numbers are cumulative.

Table 1-15 The reduction in areas inundated given Option 2

	Total Land Use hectare	Area Inundated ARI 5 year	Area Inundated ARI 20 year	Area Inundated ARI 100 year
State Forest	8,453	640	755	768
Private Forest	2,798	112	246	262
Private Non-Irrigated	31,116	1,280	3,712	4,483
Irrigation Mixed	13,250	82	644	1,384
Dairying, Pigs, High Capital	9,570	38	418	1,474
Horticulture	102	0	0	0
Special Use	310	5	25	45
Total	65,599	2,157	5,800	8,416
% inundated		3%	9%	13%

We have estimated that the *expected value* of flooding in any one year is about $2.36 million, which over 100 years suggests the following present value of damages in the future:

4% discount $57.85 million

8% discount $29.49 million

These flooding losses have been calculated assuming a reduction in areas inundation only. Option 2 is likely to also reduce the duration of inundation from an average of two to three weeks back to five to seven days. The critical time for inundation in terms of plant death varies depending on whether the water is moving, or stationary and also on the temperature of the water. The critical length of duration before plant death occurs is thus uncertain, but it is generally around 4 days for clovers and 7 days for grasses.

If we assume that the reduced duration of flooding reduces the damages caused by flooding per hectare, then the *expected value* of flooding in any one year is about $1.89 million, which over 100 years suggests the following present value of damages in the future:

4% discount $46.43 million

8% discount $23.67 million

1.3 Damages under option 3

Given Option 3, the areas inundated are reduced by the areas shown in Table 1-16. Note once again that these areas are cumulative.

Table 1-16 The reduction in areas inundated given Option 3

	Total Land Use hectare	Area Inundated ARI 5 year	Area Inundated ARI 20 year	Area Inundated ARI 100 year
State Forest	8,453	1,216	1,434	1,459
Private Forest	2,798	213	468	498
Private Non-Irrigated	31,116	6,292	19,361	26,180
Irrigation Mixed	13,250	79	1,542	3,583
Dairying, Pigs, High Capital	9,570	53	585	2,063
Horticulture	102	0	3	6
Special Use	310	6	32	70
Total	65,599	7,859	23,425	33,859
% inundated		12%	36%	52%

We have estimated that the *expected value* of flooding in any one year is about $1.23 million, which over 100 years suggests the following present value of damages in the future:

4% discount $30.23 million

8% discount $15.41 million

These flooding losses have been calculated assuming a reduction in areas inundation only. Option 3 is likely to also reduce the duration of inundation from an average of two to three weeks back to five to seven days.

If we assume that the reduced duration of flooding reduces the damages caused by flooding per hectare, then the *expected value* of flooding in any one year is about $1.03 million, which over 100 years suggests the following present value of damages in the future:

4% discount $25.22 million

8% discount $12.86 million

1.4 Summary of benefits associated with reduced flood damage

The benefits of each option is the difference between the estimated flood damages for that option and the estimate of flood damages under present floodplain management. These benefits are summarised in Table 1-17. These results have assumed no reduction in damages per hectare.

For example, the benefits from option 2 using a discount rate of 4% is equal to:

$68.70 - $57.85 = $10.86

Table 1-17 The NPV and annual expected value of the flood damage benefits from the two options.

	Present Value 4% discount (million)	Present value 8% discount (million)	Expected Annual Value (million)
Option 2	$10.86	$5.53	$0.44
Option 3	$38.48	$19.62	$1.57

The benefits have also be calculated where a reduction in losses per hectare have been assumed. These results are shown in Table 1-18.

Table 1-18 The NPV and annual expected value of the flood damage benefits from the two options given a reduction in damages per hectare.

	Present Value 4% discount (million)	Present value 8% discount (million)	Expected Annual Value (million)
Option 2	$22.27	$11.36	$0.91
Option 3	$43.48	$22.17	$1.77

2. REDUCED NUTRIENT LOADS

Floods involve the transport of substantial quantities of soil sediments and the phosphorous component of those sediments leads to increased nutrient loads for the waterbodies and waterways that receive floodwaters. Eutrophication of waterbodies and waterways is increasingly becoming a major cost to the community, particularly in terms of the toxic blue-green algal blooms that can occur in eutrophic waters.

A recent study estimated the economic impacts of toxic blue-green algal blooms associated with the Goulburn Broken catchment (Read Sturgess and Associates 1997). For waterbodies and waterways with algal cell counts above 15,000 cells per ml, response plans for toxic blue-green algal blooms require that the consumptive use of water resources is restricted. Impacts include restrictions on use for all those who enjoy values associated with the waterbodies and waterways; namely, those:

- visiting waterbodies and waterways for recreation
- farmers relying on stock water
- users of domestic water
- industrial users of water
- urban users of water
- irrigators

Read Sturgess and Associates (1997) estimated the costs of those impacts for the present nutrient loads in the Goulburn River, and downstream impacts for users of diversions from the River Murray. That study concluded that the average impact of one kg of total phosphorous in those waterbodies and waterways would lie in the range $135 to $270.

Sediment being dropped on the floodplain during floods would represent the removal of TP from the waterbodies and waterways. SMEC has estimated the quantity of TP that would be dropped on to the floodplain for each of the options, and we have valued that reduction in nutrient loads in waterbodies and waterways using the estimated $135 to $270 per kg TP:

	Expected average annual values			
	TP loads entering floodplain kg	TP loads being left on floodplain after floods recede kg	Value of nutrient loads avoided @$135/kg	Value of nutrient loads avoided @$270/kg
Existing	4,240	1,060	$143,000	$286,000
Option 2	1,920	480	$65,000	$130,000
Option 3	3,920	980	$132,000	$265,000

This reveals that both Options 2 and 3 would reduce the amount of TP being dropped on the floodplain during floods and, as such, nutrient loads in the lower Goulburn River and River Murray would be increased. The implied costs for each option would be:

	Low estimate	High estimate	
Option 2	$0.08	$0.16	million per year
Option 3	$0.01	$0.02	million per year

3. VALUES ASSOCIATED WITH LAND RETIRED FROM AGRICULTURE FOR OPTION 3

3.1 PRICED VALUES

Registered valuers possess the appropriate expertise to comment on likely market values for the land to be retired from agriculture under Option 3. SKM employed the valuers, Goulburn Valley Property Services, to "appraise the current market level of values in the Lower Goulburn River - Northern Flood Plains Area", and we believe that the report by the valuers (dated January 1998) relates approximately to the area of land to be retired from agriculture under Option 3.

The report by Goulburn Valley Property Services concluded that dry land market values for arable land are around $750 per hectare and $250 per hectare for bush land. Goulburn Valley Property Services noted that observation of actual sales have shown a range of $650 to $800 per hectare for arable land, but that there were no observations of actual sales for bush land. They based their estimate of $250 per hectare for bush land on their assessment of the value of timber on bush land.

Read Sturgess and Associates is not a firm of registered valuers, but considers that further comment about the value of bush land should be sought from the registered valuers. Our own discussions with land owners and real estate agents have indicated that, while the agricultural value or timber value of bush land may be very low, hypothetical market values for such land are better considered in terms of the average price for a farm block which includes a mix of arable land and bush land. Most owners have suggested that they would not be willing to excise the bush land component at a price lower than that which they could receive for their arable land.

In Section 3.3 below, we offer some suggestions for achieving higher market values.

3.2 UNPRICED VALUES

One of the most important features of the corridor of the Lower Goulburn River is that it is part of a Victorian Heritage River (Land Conservation Council 1991). This classification means that unpriced values of outstanding significance on the Lower Goulburn associated with natural heritage, cultural heritage, recreational and scenic values of outstanding significance are to be protected. Some key features of the Heritage River corridor along the Lower Goulburn include:

- River Red Gum forests and woodlands of State significance;
- a large number of significant species of native fauna and flora (including rare, vulnerable and endangered species, notable amongst which are the squirrel glider, Murray cod, and possibly Barking Owl and Powerful Owl);
- nationally important wetland systems;
- numerous aboriginal archaeological sites of high significance and significant sites for reasons related to agriculture and water supply;

- high values for fishing[1], particularly for native species, over the entire reach and for duck hunting around Shepparton;

- opportunities for a wide range of recreation activities including scenic driving, bird watching, canoeing[2] and camping; and

- high scenic values associated with the River Red Gum and box forests.

Implementing Option 3 could affect unpriced use and non-use values[3] in two general ways, namely:

1. enhancement of those values on the acquisition area resulting from the establishment of a more "natural" environment on the acquisition area; and

2. reduced damage to these values in the Heritage River corridor of the Lower Goulburn river if there were diminished bank erosion due to changes in the flooding regime of the river.

The extent and timing of these effects cannot be predicted with certainty but it is possible to gain an impression of the order of magnitude of the benefits which might be achievable. Some effects would be long-term, for example, the improved wildlife habitat and improved scenery which would result from improved regeneration of Red Gum forests on the acquisition area. Other effects might be realised more rapidly, for example, any reduction in the rate of bank erosion on the Lower Goulburn (for an evaluation of the implications of such erosion see Read Sturgess and Associates 1998).

In relation to use values arising from recreation activities, it is not easy to predict before the event whether a net increase in value would occur or whether the realisation of value would merely be shifted from one area to another. For example, if increased flooding on the acquisition area were to increase the number of visits for duck hunting over the whole Lower Goulburn region, a real benefit would have occurred. On the other hand, if the only effect was that some duck hunters shifted their activity from, say, Reedy Swamp to a swamp in the acquisition area, no increase in the aggregate value of duck hunting would have occurred. In the latter situation, however, it is conceivable that there may be reduced pressure on access points to the main river and its existing wetlands which may assist with the recovery of vegetation.

The two types of effect are considered below for various values which are important in relation to the characteristics of the Lower Goulburn as a Heritage River.

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1 See Tunbridge, Rogan and Barnham 1991.

2 See McLaughlin and McLaughlin 1991.

3 Non-use values are those arising from the fact that people are prepared to pay to ensure the existence of environmental assets, whether or not they make use of those assets.

3.2.1 Wetlands

13,000 ha of the Lower Goulburn floodplain is regarded as a "nationally important" wetland (ANCA 1996). Wetlands are judged to be nationally important if they meet at least one of six criteria. The Lower Goulburn floodplain was judged to meet two of the required criteria, namely:

- it is a good example of a wetland type occurring within a biogeographical region in Australia; and
- it is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.

The present management of floods in the proposed acquisition area reduces the frequency and duration of inundation. As a result the areas of various types of wetland on the floodplain are less than they might be if the frequency and duration of flooding were increased.

The total economic value of wetlands can be considered to be composed of three elements (Pearce and Turner 1990):

- *direct use value* - expressed in terms of the environmental commodities and amenities of direct use to humans, such as the recreational opportunities;
- *indirect use value* - such as the values associated with life support and pollution assimilation functions of wetlands; and
- *non-use values* - such as the value people place on the existence of a wetland whether or not they use it.

Although we are focusing attention on use and non-use values of wetlands the importance of indirect use value needs highlighting. For example, Jensen (1993) notes that recent estimates in the United States put the value of wetlands for flood retention buffers at A$19,285 per ha and up to A$286,000 per ha for nitrogen retention. Jensen also cites a demonstration by the US Army Corps of Engineers that intact wetlands stored 70 per cent of a 1 in 2 year flood, providing a cheaper and more effective method of flood mitigation than levees. Other studies in the US, have shown high values - up to US$14,600 per ha (1971 values) for the life support values of forested wetlands (see Young 1991).

A study of the wetlands of the nearby Barmah Forest using contingent valuation procedures found a value for the preservation of the wetlands of about $3,000 per ha (Stone 1992). It may not be appropriate to transfer this value to the wetlands of the Lower Goulburn because the Barmah wetlands are listed under the RAMSAR Convention. This listing means they are deemed to have international significance for waterbird populations, as representative or especially significant for their ecology, botany, zoology, limnology or hydrology. More conservative values have been used in other studies of wetlands which are not classified under the RAMSAR Convention (McGregor, Harrison and Tisdell 1994)[4].

By way of illustration, a value of $2,000 per ha was used elsewhere (Read Sturgess and Associates 1998), as an indicative value for the nationally important wetlands of the Lower Goulburn Floodplain. This suggests a value of about $26 million for the preservation of the Lower Goulburn wetlands.

How the area or the value of these wetlands might change as a result of increased flooding in the acquisition area is unknown. Nevertheless, the above discussion indicates that a valuable asset could be enhanced. The acquisition area includes an important component of the Lower Goulburn wetlands associated with systems of recent streams, including presently ephemeral streams, such as Sheepwash Creek, and more permanent streams (at least in parts) such as Deep Creek.

If the value of the acquisition area, as wetland, were to be increased by an average of $1000 per ha, whether by enhancing existing wetlands or re-instating others, the increase in capital value would be about $1 million.

3.2.2 Flora and fauna

Regularly inundated sites on the Lower Goulburn floodplain support grassy woodland vegetation dominated by River Red Gum and, in higher sites, by various species of Box. These types of woodland have been extensively cleared so that relatively little of the original cover remains. What does remain is nationally significant because of the botanical community and the animal life it supports.

The values represented by the biodiversity of these communities cannot be considered separately from the value as wetland but are complementary. Again, it is possible to demonstrate that considerable value may be represented by some of the species of flora and fauna.

Significant mammals

A number of significant species of mammals occur in the River Red Gum forests that line the Lower Goulburn. Amongst these is the squirrel glider, which is classified as vulnerable in Victoria. Squirrel gliders tend to live in hollows in Red Gums and feed on Silver Wattles which grow in association with Red Gums in the riverine forests. River Red Gum forests are also habitat for the rare brush-tailed Phascogale which needs tree hollows for nesting. It is susceptible to predation if there is a decline in suitable hollows. Similarly, the rare large-footed Myotis which is associated with slow-flowing water bodies is vulnerable to reductions in the over-story vegetation in which it roosts.

Increased areas of these plant communities in the acquisition area as a result of increases in the extent and duration of wetting, may help assist in the viability, growth and geographical spread of populations of squirrel gliders and other rare mammals. Reduced rate of loss of Red Gum communities on the main river may assist in the rebuilding of populations.

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4 Even so, not all high-value wetlands are listed under Ramsar.

Again, expansion of appropriate habitat near the recent streams in the acquisition area may be particularly important because these streams function as wildlife corridors. Furthermore, The Lower Goulburn corridor is included in one of seven "biolink" zones described for Victoria in the Flora and Fauna Guarantee Strategy. Biolink zones are defined as areas where there is high priority to consolidate and extend existing native vegetation in order:

- to enhance the viability of species and ecological communities under current climate regimes; and
- to improve the viability of ecological communities and species or groups of species under future climatic regimes.

There are no studies which have attempted to value the preservation of the squirrel glider, the brush-tailed Phascogale or the large-footed Myotis. However, a local study which attempted to assess willingness to pay for the preservation of a mammalian species was that of Jakobsson, Kennedy and Elliot (1995). These authors estimated that Victorians would be prepared to pay between $29.4 and $75.7 per household per year to preserve Leadbeater's possum. This meant that for Victoria as a whole the value ranged from $40 million to $103 million per year. They also estimated Victorian's willingness to pay to prevent extinction and be certain of the survival of the Eastern barred bandicoot at $34 million.

These figures show that Victorians are prepared to pay to ensure the survival of particular mammalian species - albeit species with what might be termed a "high public profile" (Leadbeater's possum is Victoria's faunal emblem). We cannot argue from willingness to pay for the preservation of one species to the willingness to pay for the potential expansion of habitat and, therefore, potentially larger populations of another species. Nevertheless, the above figures are indicative that Victorians might be prepared to pay significant amounts for this purpose. Possible orders of magnitude can be explored by several "what if" scenarios.

For example, "what if" residents of the Shires containing the Lower Goulburn (say, Strathbogie, Greater Shepparton and Moira - about 30,000 households) were prepared to pay an average of $5 per household per year for thirty years to avoid the threat posed by bank erosion to the habitat on the Lower Goulburn of the squirrel glider, the brush-tailed Phascogale and the large-footed Myotis (a total of $0.15 million per year). This figure for three species is equivalent to one-sixth of the lower bound of the valuation of Leadbeater's possum. If increased inundation of the acquisition area was the mechanism whereby this threat was alleviated, then the present value of the benefit (at a discount rate of 4 per cent) would be about $2.6 million.

Other "what if" scenarios are shown in Table 3-1.

Table 3-1 Present values of hypothetical willingness to pay by local households for preserving habitat for terrestrial fauna on the Lower Goulburn

	"What if" catchment households were willing to pay $2 per year for 30 years	"What if" catchment households were willing to pay $5 per year for 30 years	"What if" catchment households were willing to pay $10 per year for 30 years
Present value at 4 per cent discount rate	$1 m	$3 m	$5 m
Present value at 8 per cent discount rate	$0.7 m	$2 m	$3 m

These figures do not include any amounts that households outside the Lower Goulburn region might be prepared to pay for the same purpose.

<u>Birds</u>

A large number of significant bird species inhabit the river corridor and floodplain of the Lower Goulburn. The river forms an important breeding area for many water birds. Included amongst the significant bird species are: the White-bellied Sea Eagle, the Brolga, the Royal Spoonbill, the Barking and the Powerful Owls, and various types of Ibis.

Studies in the USA of endangered bird species have shown the following unit values - expressed as annual values per household in 1993 dollar values (Loomis and White 1996):

Northern Spotted Owl	$70 per year
Whooping Cranes	$35 per year
Red-cockaded Woodpecker	$13 per year
Bald Eagles	$24 per year
Striped Shiner	$6 per year

Unfortunately, we have no reasonable way of arguing from these species to, say, the rare birds of the Upper Goulburn. Again, however, the figures indicate that people are willing to pay significant amounts for the preservation of endangered species.

The possibility of increased duck hunting has already been mentioned. To the consultant's knowledge there are no Australian estimates of hunters' willingness to pay for a duck-hunting trip. Estimates from the US, however, suggest that duck hunting is a relatively highly-valued activity with mean net economic value per recreation day of about $US35 (measured in 1987 dollars - see Walsh *et al.* 1992).

Native fish

The Lower Goulburn provides one of the most important habitats for native fish in Victoria. Nevertheless, there is concern about a number of species of native fish which exist in the Lower Goulburn, including:

- Murray cod (vulnerable);
- Silver perch (vulnerable);
- Freshwater catfish (vulnerable)
- Golden perch (rare);
- Bony bream (rare); and
- Flat-headed galaxias (rare).

Murray cod, one of the best-known native fish, even amongst non-anglers, is listed under Schedule 2 of the *Flora and Fauna Guarantee Act* 1988.

Some of these fish, including Murray Cod and Golden Perch, move out of the main channel during floods and utilise the floodplain. The acquisition area has the potential to increase the area of the floodplain available to fish. Native fish also benefit from the supply of invertebrates in floodwaters which return to the river as floods recede. The potential to increase populations of invertebrates from increased frequency and duration of flooding on the floodplain could, in turn, influence the size of fish populations.

To the consultant's knowledge there has been no study of the value of preserving particular species of freshwater fish in Australia. Most of the overseas studies on preservation values have involved marine mammals, such as dolphins and whales. Some notable exceptions are the Colorado squawfish and the Arctic grayling and cutthroat trout (see Loomis and White 1996). It was estimated that Colorado households were willing to pay $8 per year (measured in 1993 dollars) to avoid the loss of squawfish. One-off lump sum contributions from US visitors for river improvement to preserve the Arctic grayling and cutthroat trout were assessed at $15 per household ($US1993).

Read Sturgess and Associates (1997) conducted a pilot study in the Goulburn-Broken catchment to determine householders willingness to pay to protect the *habitat* for platypus and native fish[5]. The study was conducted in the cities of Shepparton, Seymour and Benalla and revealed an average willingness to make a one-off contribution to a fund for this purpose of about $11 per household. Using the number of households in the Goulburn Statistical Division from the 1996 census, namely, 75,098, this average figure suggests a total willingness to pay across the Goulburn-Broken catchment of about $800,000.

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5 Copies of the pilot study are available on request from Read Sturgess and Associates, 89 Gladstone St., Kew, Vic. 3101

We do not know what proportion of this amount could be attributed to the Lower Goulburn waterway. Given its status as a Heritage River, however, we believe 25 per cent might be a reasonable "guesstimate" for the valuation of the residents of the Goulburn-Broken catchment.

The most important use value associated with native fish is that due to recreational angling. Similar to the situation for duck hunting, it is difficult to predict the degree to which recreational angling might be enhanced if fish stocks were to increase due to greater frequency and duration of floods on the acquisition area. Recreational fishing is also a relatively highly-valued activity (see Walsh *et al.* 1992 and for an Australian valuation, see Sinden 1990).

Other use values

Other use values which might be encouraged by appropriate management of the acquisition zone under increased frequency and duration flooding would include sightseeing, picnicking, 4 wheel driving, trailbike riding, camping and bird watching. Careful consideration of access to the corridor of the main river and the acquisition zone, and siting of facilities for these purposes, could lead to greater opportunities for these purposes than exist at present.

Potential dis-benefits associated with Option 3

Some potential negative effects associated with Option 3 might include the following.

- Loch Garry might not be flooded to the same height as frequently as it is now. This may reduce the habitat for bird life on the Loch and its surrounds but this would need to be off-set with the potential to improve habitat on the acquisition area.
- The realisation of environmental benefits on the acquisition area may be affected adversely by intense grazing.
- Increased production of native vegetation which can be expected from increased frequency and duration of flooding in the acquisition zone may increase the risk of bushfires in the zone. Thus, sophisticated management strategies which balance increased native vegetation, grazing intensity and the risk of fire may be required.
- Any disbenefits resulting from lower water levels in existing wetlands.

3.3 POTENTIAL FOR SELLING LAND FOR NON-AGRICULTURAL USE

We have had discussions with the Trust For Nature, which is a non-profit organisation which aims to protect environmental values on private land. Its activities include mainly:

1. working with property owners to assist them in placing conservation covenants on land, and

2. purchasing land in order to protect it with conservation covenants prior to re-selling the land.

The Trust For Nature finds that there is a solid market for bush blocks, with buyers generally being either individuals seeking sites for weekend retreats, or co-operatives who seek simply to own a block where environmental values are being protected (sometimes even if the members of the co-operative do not or cannot use the land). That is, the market encompasses both use values and non-use values.

As mentioned in Section 3.2, there would be substantial environmental values associated some sites in the land to be retired from agriculture under Option 3. It is likely that some parcels of bush land could be purchased by the Trust For Nature or by co-operatives, for their non-use values. Residential development would probably not be appropriate on any of the land to be acquired, but there remains the real possibility that some of the land could be sold in small, say 2 hectare, blocks as camping sites for individuals who desired exclusive property rights to particular camping spots. This would most likely be popular to hunters. According to the Trust For Nature, the likely prices paid for small blocks, for camping sites or for sanctuaries, would be much higher than prevailing agricultural values.

Much of the land could be managed as Red Gum plantations and so remain in productive use.

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APPENDIX B:

Biodiversity Benefits of the Modified Findlay Scheme

BIODIVERSITY BENEFITS FOR THE GOULBURN-BROKEN CATCHMENT OF THE MODIFIED FINDLAY SCHEME.

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APPENDIX B

1. GENERAL

1.1 Introduction

The lower Goulburn River and associated floodplains are a highly modified system, with a long history of disturbance and modification. Despite this, the wider area of lower Goulburn remains one of the most environmentally important regions in Victoria, containing areas of habitat of State and National Significance for threatened flora and fauna. The remaining forested area of the floodplain is recognised as a critical 'biolink zone' providing a continuous, inter-bioregional linkage between the forested foothills and highlands of the Great Dividing Range to the south and the Murray River to the north. The area also provides critical habitat for a range of threatened species and contains a number of examples of vegetation types that are depleted throughout the catchment.

The Option 3 (Modified Findlay Scheme MFS) proposal to re-instate more natural flooding regimes is likely to result in a substantial net gain for biodiversity conservation in the Goulburn Broken catchment. The MFS has the potential to provide a wide range of direct and indirect benefits to the wider community. These benefits are outlined below.

1.1.1. Restoration of more natural flows to the lower Goulburn River.

Current flow rates in the Goulburn River leveed system during flood events result in increased water levels and velocities, which in turn leads to the loss of bank and in-stream vegetation, erosion and destabilisation of banks, erosion of stream bed structure, loss of in-stream habitat and debris. These impacts contribute to the further degradation of the in-stream and riparian zone ecosystems. Similarly, accentuated flows through the creeks and prior streams on the near floodplains may impact on these areas in a similar manner. Re-instatement of more natural flows to the lower Goulburn River and floodplain is likely to ameliorate these issues and improve habitat management for a number of threatened or depleted species.

Additionally, restoring flooding regimes to the near floodplains is also likely to have broader implications for ecological processes in wetland ecosystem, vegetation community composition, and flora and fauna reproduction cycles dependent on natural flooding of these areas.

1.1.2. Restoration of more natural flows to the MFS floodplains.

The MFS floodplain areas including the creek and wetland ecosystems, evolved in response to the natural flooding regime that existed prior to the construction of levees along the Goulburn River. These flooding regimes however, have been substantially modified since the construction of the levees and the floodplains are now flooded only during moderate to major flood events. The strategic removal of levees would allow more natural flow regimes to be restored, which is likely to have benefits for wetlands, creeks and other floodplain ecosystems that have been deprived of flooding and the species which rely on these habitats.

1.1.3. Protection of significant, depleted vegetation types, threatened and declining species habitats.

The Lower Goulburn and the MFS areas provide habitat for a range of threatened flora and fauna species. The large amount of remnant vegetation, the diversity of habitat types, the size of individual patches and the configuration and connectivity of habitat through the MFS area mean that this area is unique in the lower Goulburn Broken Catchment. The area contains habitat or vegetation types that are of Local, State and National Significance, including some areas that have been nominated to the National Estate Register.

Although no formal detailed flora and fauna surveys have been carried out, limited surveyus, current records and expert knowledge of the areas suggest that the purchase and more 'appropriate' management of the MFS areas will provide protection for a number of threatened and declining species and depleted habitat types. Currently, habitats on private land within the MFS areas are managed primarily for purposes *other* than conservation. Continual grazing, cropping and development in these areas are resulting in further loss and fragmentation of remnant vegetation and contributing to the decline of threatened species.

If the purchase of the MFS areas proceeded, important habitat areas can be managed primarily for conservation. Key sites could be fenced and buffered from external influences by revegetation that is likely to substantially increase the viability of these areas.

1.1.4. Reduced disturbance by levee maintenance and restoration works.

The current levee system requires on-going maintenance and emergency repair work, as was the case in the 1993 flood event, which included emergency repairs and major levee restoration work. (financed under the Natural Disaster Relief Fund). While necessary, these repairs can have significant environmental impacts, including the destruction and removal of native vegetation, soil disturbance, excavation of soil from the floodplain and weed invasions.

With the reduction of the rate of flows in the Goulburn River under the MFS, the likelihood of levee failure would be substantially reduced, which in turn would include reduced disturbance by levee maintenance and restoration works. Furthermore, if the current levee system is retained and the river channel continues to erode and under cut banks, levees will require relocation in a number of areas. Again this will require the removal of native vegetation and further soil disturbance.

1.2 Indirect Biodiversity Benefits

The MFS proposal also has a range of indirect benefits for biodiversity in the Goulburn-Broken Catchment outlined below.

1.2.1. Changes to management of floodplain ecosystems and other areas of public land in the lower Goulburn area.

The preferential clearing of land suitable for agriculture means that few areas of public land remain in the Goulburn-Broken catchment. Where public land does exist, it is generally in areas unsuitable for intensive agricultural production, such as land prone to inundation by floodwater. Consequently, the vegetation types occurring on land suitable for agricultural production have been severely depleted. In particular woodlands and grassland complexes have been severley impacted. Plains Grassy Woodland is a Broad Vegetation Type (BVT) that has been substantially depleted with less than 1% remaining across the Victorian Riverina Bioregion. The MFS areas contain a number of areas of Plains Grassy Woodland BVT and other depleted vegetation types. The MFS represents a unique opportunity to purchase land with depleted BVT's or threatened species habitats. While the purchase of significant areas as a conservation measure has been widely advocated as Best Management Practice in Australia, in reality there have been few opportunities to seriously consider the purchase of large areas of land. In conservation terms, the purchase of land from private landowners is considered a highly effective strategy, removing the 'uncertainty' of private management of environmentally valuable areas. Furthermore, the purchase of single patches or blocks in the landscape does not address the impacts of adjacent land uses. The broader scale purchase of land however allows for coordinated management of areas incorporating the surrounding landscapes. For example, large scale coordinated fox baiting programs across large areas would have major benefits for biodiversity, but is currently impossible to achieve.

The MFS areas could also be managed for a range of other uses, which relieves recreational and other utilisation pressure on the limited areas of public land in the lower Goulburn-Broken catchment. For example, the transition of grazing and agistment, firewood harvesting and some timber extraction from other significant areas of public land to the MFS area would have major benefits for biodiversity in the catchment. The wider benefits of more appropriate management of areas of public land will also have benefits for tourism and recreation activities on public land in the lower catchment.

1.2.2. Increased tree cover.

Allowing large areas of the MFS to regenerate naturally with River Redgum following major flood events would provide future timber and firewood resources, again relieving pressure on existing areas of public land. Further, increasing tree cover in the lower catchment, where native vegetation cover as declined to less than 4% of its original extent will have major benefits for biodiversity for the catchment. Current research suggest that between 10 and 30% tree cover is required to maintain current levels of biodiversity in agricultural landscapes. This level of tree cover could easily be achieved within the MFS areas without compromising other management objectives. This would make a significant contribution to the broader objectives of the catchment and the Victorian Biodiversity Strategy by restoring the balance between the past clearing of native vegetation and revegetation and regeneration of cleared land.

1.2.3. Carbon-credits

There is considerable interest by industry and corporations in the issues of greenhouse gas emission trading and off-sets. Under the Kyoto Protocol, a system of emissions trading and crediting is being developed. Under this system industries that are required to reduce their total greenhouse gas emission levels may seek to invest in revegetation schemes that sequester carbon as a way of off setting carbon emissions from their other activities. The carbon sequestered by the vegetation regenerating on the MFS could be 'claimed' by a company for an annual fee per tonne of carbon. This is an emerging concept and there are still a number of policy and legislative issues to be resolved by government before this system will be full operational. There maybe considerable interest from companies also wishing to improve their 'green' image.

2. FLOODING IMPACTS OF THE MODIFIED FINDLAY SCHEME ON THE MURRAY RIVER

2.1 For Major Floods - Impacts of the Modified Findlay Scheme

The geomorphology of the floodplain as described in Section 2 and presented in **Figure 2.1** dictates the nature of flooding for major flood events, particularly when levee failures occur.

During major floods such as those that occurred in 1974 and 1993, the bars from the Loch Garry regulator were totally removed to allow floodwater to escape from the river-leveed system into the northern floodplain. In addition, unpredictable flooding also occurred due to the river-leveed system being overwhelmed which in turn caused random widespread levee failures. Having regard to the natural features of the floodplain, floodwater arriving at the Murray River during such events would inevitably occur with or without the Modified Findlay Scheme in place.

The design of the Modified Findlay Scheme deliberately leaves a gap in the proposed left side bund of the Deep Creek Floodway where the You You Creek entres the Deep Creek system refer to **Figure 6.1.** The reasoning behind this feature of the design is as follows.

The combined flood flow of the Murray River, Deep Creek Floodway and Goulburn River needs to pass through the Bama sand Hills (refer to Figure 2.1). The most effective way of achieving this is result with the lowest average flood levels upstream of the Bama Sand Hill is to allow flood waters in a major flood to find an equilibrium level. This would be achieved by linking the Murray / Deep Creek system with the Lower Goulburn at the You You Creek.

2.2 For Minor Floods - Impacts of the Modified Findlay Scheme

For minor flood, the impacts of the Modified Findlay Scheme are those impacts created be releasing floodwater through the Loch area without the Loch in place.

Flood overflows would commence approximately on an annual basis. Unlike flood flows through the Loch Garry regulator, floodwater would leave the Loch area at general ground level elevation, and be widespread over several kilometres as gentle overland flow, rather than high energy confined flow.

For small floods, the travel time to the Murray River along the northern floodplain would be considerable less compared with floodwater that would otherwise remain in the leveed Goulburn River channel (assuming the levee remains in tact). The Modified Findlay Scheme has therefore benefit in that flows are reduced in the Goulburn River and attenuated in the floodplain.

3. OVERVIEW

The Goulburn-Broken catchment covers 2.3 million ha or about 10% of Victoria. The upper parts of the catchment produce a water resource of 2 800 000 ML which is utilised for a variety of purposes in the Murray Valley, Shepparton, Central Goulburn and Rochester irrigation areas and by other users further to the west and downstream along the Murray River. The catchment is only 2% of the Murray Darling Basin but supplies 11% of the Basin's streamflow.

The Goulburn Broken catchment is one of three high priority catchments targeted by the Murray Darling Basin Ministerial Council's Algal Management Strategy to develop and implement catchment management strategies addressing algal and nutrient problems.

The National Water Quality Management Strategy, the MDBC Water Quality Policy, the MDBC Algal Management Strategy and the Victorian Nutrient Management Strategy have been formulated to address the water quality and nutrient management problems. With these policies and strategies in mind, the Goulburn Broken Water Quality Working Group has set the following goals:

- minimise blue green algae outbreaks in the Goulburn-Broken catchment;
- minimise/optimise water treatment costs;
- minimise nutrient contributions to the Murray River;
- foster regional development (by ensuring quality water to industry, agriculture and the community); and
- enhance the riverine environment.

Other water quality issues include salinity, acidity, biocides, turbidity, viruses, "black water events" and pest water plants and carp.

Water Quality and Nutrient Benefits

In a recent publication Living on Floodplains (CRC for Fresh Water Ecology & MDBC), indicates floodplains are essential for the well being of river health.

Floodplains not only supply food to rivers, they also seed rivers with living organisms, replenishing those washed downstream or eaten. Microoganisms on floodplains also remove potential pollutants from water, maintaining the natural chemical balance of rivers. Such feeding and cleaning services go unnoticed in healthy rivers, but when they are turned off the results may be disastrous.

River stripped of their natural clean-up mechanisms become breeding grounds for undesirable organisms, large and small, and their water become contaminated with pollutants. Waterborne human and animal diseases flourish in a changed aquatic environment, while problems normally kept in check by natural biological controls burgeon out of control.

The Modified Findlay Scheme has two major benefits in terms of improving water quality. The first is due to expelling excess floodwater on a more frequent basis, (approximately on an annual basis) on to the adjoining floodplains. Floodwater across the floodplains will be stripped of its suspended sediment and nutrient material as its flow velocity reduces. In the long term as the floodplains become more vegetated, they will become more efficient sediment and nutrient strippers, which will provide benefit to the floodplain.

The greatest benefit derived by sediment and nutrient stripping is for the frequent flood events as they contain higher concentration of nutrients and sediments compared with major diluted food events.

The second benefit is that there would be the inherent improvement of water quality in the Goulburn River entering the Murray River.

4. DISBENEFITS OF THE MODIFIED FINDLAY SCHEME

4.1 Environmental Disbenefits

Environmentally there may be some interim negative impacts caused by the MFS as outlined below.

- **Changes to current flooding regime of floodplain wetlands may have interim impacts.** The current system, while disturbed by changed flooding regimes and other activities, is likely to have reached some form of equilibrium. Changes to flooding regimes associated with the MFS will result in changes to the current floodplain and river ecosystems. These changes may have negative impacts in the short term; however, the benefits of the longer term goal of restoring more natural flows to the lower Goulburn area outweigh these short term impacts as described in **Section X.X**

- Increased flows across the northern floodplain may result in some erosion and loss of environmental values in the short term. Due to the current management within the MFS area, many of the floodplain flood ways have poor vegetation cover. These areas may be susceptible to erosion and transportation of material. The removal of grazing from some sites and the possible revegetation of areas may alleviate these issues.

- There is potential for environmental damage to occur during the earth works associated with the scheme. The removal of levees, the construction of bundings and control structures could have significant impacts if planned and sited. These works would need to be strictly managed ensure that no adverse environmental impacts occur on any sites of environmental, cultural or heritage significance. The works would need to be subject to detailed environmental impact assessment and conducted in accordance with Best Practice guidelines. However, in the long term there would be reduced need for levee restoration and maintenance as described in **Section X.X** .

4.2 Social Disbenefits

The areas within the MFS that would be subject to increased flooding regimes compared to the current conditions would be purchased. This scheme could lead to substantial social disruption if not correctly managed. Prior to the scheme implementation, extensive consultation with detailed investigation would be required, and include detailed analyses of property valuation, relocation and disruption to family allowances.

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