DEPARTMENT OF LAND AND WATER CONSERVATION
SPECIALIST COASTAL AND FLOOD SERVICES BRANCH

EDWARD AND WAKOOL RIVERS FLOODPLAIN MANAGEMENT STRATEGY

NOORONG ROAD TO WAKOOL MURRAY JUNCTION

JULY 2000

Cover Photograph:

Flooding near “Coobool Island” on 27th October 1993. The Wakool River, Pissen Creek and Mallan Creek are shown.

EXECUTIVE SUMMARY

Background

The strategy is the fourth (Stage IV) in a series of reports dealing with floodplain management issues on the Central Murray floodplain. The Stage IV area covers the downstream part of this floodplain. It includes the floodplain of Merran Creek and the lower Edward and Wakool Rivers.

The development of agriculture on the floodplain has seen the widespread and uncoordinated construction of works that have affected the natural distribution of floodwaters. This has substantially increased the potential for flood damage to developed areas. It has also impacted on floodplain ecosystems that depend on flooding for their sustenance.

The NSW Department of Land and Water Conservation (DLWC) has prepared this strategy in line with its responsibilities in administering the *Water Act*. The Central Murray floodplain is designated under Part 8 of this Act. All private earthworks on the floodplain that could affect the distribution of floodwaters require licensing under this Act.

The strategy has the following objectives:

- to provide floodways with adequate capacity for the orderly passage of floodwaters;
- to maintain and restore, as far as practicable, the natural pattern of flooding;
- to enable flood protection for agricultural land and other property;
- to enable flooding to support the floodplain environment, particularly flood-dependent ecosystems;
- to implement floodplain management consistent with the planning principles of *Murray Regional Environmental Plan No 2* (Murray REP2); and
- to implement floodplain management consistent with State natural resource management policies.

River Management Plan

Murray REP2 is of particular relevance to this strategy. It provides a co-ordinated planning approach for development that may impact on the riverine environment. Under the REP, works that can affect the distribution of floodwaters (flood control works) require development consent from the local Council. The Murray - Darling Basin Commission (MDBC) has endorsed the strategy as a *River Management Plan* under Murray REP2. This means that the strategy must be taken into account when development applications for flood control works are processed. The community and government agencies with interests in floodplain management have been

consulted and have provided comment during the development of the river management plan.

The strategy shows areas of the floodplain, known as floodways, where floodplain works will only be permitted following a detailed assessment of impact showing that they are consistent with the planning principles of REP2. The strategy also identifies *hydraulically sensitive areas* where existing flood control works can significantly affect the behaviour and distribution of floodwaters. Where these areas include government - owned works, such as roads, the strategy makes specific recommendations to modify the works to address flooding impacts. Where the areas contain private works, the strategy sets out a process of further consultation and analysis with a view to modifying the works to alleviate flooding impact.

Hydraulic Design

The floodway layout has been hydraulically designed to pass a flow of similar magnitude to the 1956 flood at a level no greater than the highest known flood level at a particular site. The 1956 flood has been the largest in the area this century and has caused the most widespread disruption and damage. It was not possible to meet the floodway design criterion throughout the entire Stage IV area. At a number of sites an acceptable flood level above the highest recorded was adopted as a compromise.

Floodway widths were determined from an analysis of flood flow data, surveyed flood levels, flood slopes and cross-sectional survey of the floodplain. Most of this data was collected during and after the 1993 flood, which reached record levels in some parts of the floodplain.

By providing adequate floodway capacity, the strategy will minimise the risk of the flood wave being increased or accelerated to unacceptable levels. This is an important social benefit since it reduces the risk of catastrophic flood damage.

Environmental Assessment

Aside from the environmental effects of agricultural development, the floodplain retains important ecological values. It contains large tracts of forested riverine land, a significant number of productive wetlands, and a diverse range of fauna. Up to six threatened plant species and 26 threatened animal species may occur in the area. The floodplain also has considerable heritage value, having once supported a large Aboriginal population.

Implementation of the strategy is likely to result in significant widening of the existing floodway. This will potentially expose an additional land area of up to 2000 hectares to periodic flooding. It will enable the potential regeneration of native vegetation and would be expected to benefit fish and waterbirds by increasing food supply during floods. It will also increase habitat opportunities for forest and woodland fauna species. Additionally,

the strategy is expected to restore a flooding regime to 18 small wetlands, enabling their ecological value to be enhanced.

A number of wetlands have been blocked from flooding and are used for agricultural production. Because of potentially high economic and social impact, 7 large wetlands and 25 small wetlands were not included in the design floodway. The continued blockage of the wetlands, however, is contrary to the planning principles of Murray REP2. The strategy has mapped these former wetlands as *areas of possible wetland value* and sets out a process for their further environmental assessment when associated works are assessed for licensing purposes. DLWC will take a co-operative and pragmatic approach in exploring potential options for the return of seasonal flooding to these areas. The strategy also highlights government - owned works affecting flows to *areas of possible wetland value* so that relevant agencies can consider these areas when planning modifications to the works.

Similarly, a number of block banks, constructed across ephemeral streams to provide water storage, access or flood protection have been retained in the floodway. These banks, however, affect fish passage and also contravene Murray REP2 principles. They will undergo further environmental assessment when *Water Act* licences are assessed or renewed. These assessments will be referred to NSW Fisheries for comment.

Subject to further site - specific environmental assessment, implementation of the strategy is not expected to have any significant adverse environmental impacts.

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Mapping Acknowledgement:

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Further information on River Murray Mapping can be obtained from:

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LIST OF TABLES

1. INTRODUCTION

1.1. General

This strategy addresses floodplain management issues in the Stage IV area of the Edward-Wakool Rivers floodplain. This area includes:

- the floodplain of the Wakool River and Merran Creek downstream of Noorong Road;
- the Edward River floodplain downstream of "Liewah"; and
- the Murray River floodplain from the Wakool Junction to "Windomal".

Figure 1 shows the location of the Stage IV area.

The floodplain management strategy sets out a plan for the control of works that affect the distribution and behaviour of floodwaters. These works include levees, channel banks, block banks, roads and other earthworks. The strategy details a system of floodways on the floodplain where such works will only be permitted if supported by a detailed assessment of impact. The strategy also identifies special *hydraulically sensitive areas* where existing works can significantly affect the distribution and behaviour of floodwaters.

The strategy cannot be used as an approval for the construction of levees, channel banks, block banks, roads or any other earthworks that could alter the distribution of floodwaters.

Development consent from the local council (under *Murray Regional Environment Plan No. 2*) and approval from the Department of Land and Water Conservation (DLWC) under the *Water Act, 1912* is required for works that could affect the distribution of floodwaters on the floodplain.

1.2. Background

The floodplain area covered by this strategy lies within the Central Murray region of the Murray River Valley. This region extends west from Tocumwal to the junction of the Murray and Wakool Rivers. The main stream systems include the Edward River and Tuppal Creek to the north; the Niemur and Wakool Rivers in the centre; and the Murray River in the south. The area receives low average rainfall (300 to 450 mm per annum). Flooding is generated by high winter and spring rainfall in the upland valleys of the Murray River and its tributaries. The region supports a highly productive agricultural industry of substantial importance to the State's economy. The floodplain also has important ecological values. It contains large tracts of riverine forests and woodlands and a significant number of productive wetlands. It also supports a range of native fauna.

Development in the Central Murray area has seen a trend toward more intensive forms of agriculture, with widespread construction of channel

banks, flood protection levees and farm road systems. Much of this development has been uncoordinated, leading to significant change in the natural distribution of floodwaters. This was first observed in the early 1970s when artificially high flood levels were recorded. As a result, the Central Murray Flood Mitigation Committee asked the then Water Resources Commission to prepare guidelines for coordinated development of the floodplain of the Murray River and its effluents. The area from Tocumwal to the Wakool Junction was to be included.

The first of these guidelines investigated floodplain development on Tuppal and Bullatale Creeks (Water Resources Commission 1978). Following this, a series of guidelines on the floodplain was prepared:

- Stage I *Guidelines for Edward and Wakool Rivers Floodplain Development - Deniliquin to Moama - Moulamein Railway (Water Resources Commission 1981).*

- Stage II *Guidelines for Murray and Wakool Rivers Floodplain Development - Moama - Moulamein Railway to Trunk Road 94 (Water Resources Commission 1987).*

- Stage III *Guidelines for Edward and Niemur Rivers Floodplain Development - Moama - Moulamein Railway to "Liewah" (Department of Water Resources 1989).*

This report (Stage IV) is a strategy for floodplain management for the remainder of the Central Murray floodplain. The study area extends beyond the Wakool Junction to include the floodplain downstream to "Windomal". Figure 2 shows the area covered by Stages I to IV of the Floodplain Management Scheme.

This strategy presents the floodway layout in detail. It outlines the legislative and planning framework, the underlying concept of the strategy, the nature of development in the area, the nature of flooding, and hydraulic and environmental assessments of the floodway system. The strategy also outlines a framework for implementation and review of floodplain management recommendations.

Note:
The Poon Boon lakes, which are a series of six interconnected lakes lying between the Murray and Wakool Rivers downstream of Swan Hill, were originally included in the draft strategy. Although the hydrology of the lakes has little effect on flood levels in the Murray or Wakool Rivers, flood management is vital to the environmental health of the lakes. Following community concern with the proposed floodway through the lakes however, the DLWC recognised that further detailed analysis and consultation was required and a range of management options had to be considered. Consequently, the lakes were withdrawn from the Stage IV strategy. An environmental management plan, addressing issues associated with current

water management in the lakes, is being developed in lieu of the strategy. The local community is developing the plan in co-operation with the DLWC and the NSW Murray Wetlands Working Group.

1.3. Objectives

The objectives of the floodplain management strategy are:

- to provide floodways with adequate capacity for the orderly passage of floodwaters;
- to maintain or restore as far as feasibly possible, the natural pattern of flooding;
- to enable flood protection for agricultural land and other property;
- to enable flooding to support the floodplain environment, particularly flood-dependent ecosystems such as wetlands, riverine forests and woodlands;
- to implement floodplain management consistent with the planning principles of the *Murray Regional Environmental Plan No 2*, and
- to implement floodplain management consistent with State natural resource management policies.

2. LEGISLATIVE AND PLANNING CONTROLS

2.1. The Water Act

The Murray-Edward-Wakool floodplain was designated under *Part 8 of the Water Act, 1912* in 1984. This meant that all private earthworks that could affect the distribution of floodwaters required an approval from the then Water Resources Commission. A "controlled work" is defined as any earthwork, embankment or levee (except those excluded by "prescription") constructed on a designated floodplain or on the bank of a river or lake. "Controlled works" can include levees, supply channels and roads. Works excluded by "prescription" include railways and associated bridges vested in the State Rail Authority; and roads, associated bridges and works vested in a local government council or the Roads and Traffic Authority. All constructed and proposed "controlled works" require approval from DLWC.

2.1.1. Amendments to the Water Act

A recent review of Part 8 legislation has shown it to be limited in effectiveness and resource intensive due to the narrow compliance test that is used to assess works. This has restricted DLWC's ability to control many works that affect floodplain functions. (An estimated 80% of existing "controlled works" in the Stage IV area are unlicensed.) This situation has been redressed by the passing of the *Water Amendment Bill (1999)* which will allow for the control of rural floodplain works in a strategic, streamlined and resource efficient way.

Key features of the amendments to Part 8 include:

- expansion of the issues that should be considered when determining Part 8 applications;
- streamlining the procedures for dealing with applications, and
- strengthening DLWC's ability to prosecute or otherwise deal with unauthorised works.

The changes to Part 8 will commence to apply when the amended Act is formally proclaimed in the near future. At that stage, DLWC will publish a brochure to inform the community about the details of the amendments.

2.2. Murray Regional Environmental Plan No 2

Murray REP2, which applies to riverine lands of the Murray River and its effluents, was gazetted in 1994. The REP establishes the process for a consistent and coordinated approach to environmental planning and assessment along the River Murray.

The REP defines "flood control works" as works that change the natural or existing condition or topography of land and that are likely to affect the

hydrology of the River Murray system. This includes the construction or alteration of levees, channels or mounds.

Development consent from the local council is required to construct or alter private "flood control works". The planning principles and consultation processes of Murray REP2 apply to works vested in local or State government agencies (that is, bridges, roads, railways and associated works).

Murray REP2 places controls on the clearing of native vegetation and the management of wetlands. The REP requires development consent for wetland subdivision, and wetland clearing, dredging, draining or filling. It also places controls over particular developments on flood liable land. These include the use of land for hazardous or offensive industry, for a hazardous or offensive storage establishment, landfill, manufactured home estates, intensive livestock keeping and chemical, fuel or fertiliser storage. The REP defines flood liable land as that land inundated by the extent of a 100 year return period flood.

It is important to note that the specific provisions of Part 3 of Murray REP2 regarding wetlands and vegetation only apply to part of the Stage IV area at present. These provisions will apply to the remainder of the Stage IV area when detailed mapping of wetlands and vegetation in the area has been incorporated into the REP. Detailed mapping of the extent of flood liable land is currently being prepared. The provisions relating to flood liable land will apply when this mapping is incorporated into the REP. The general provisions in Parts 1 and 2 and for consultation in Part 3 apply at present.

2.2.1. River Management Plan

The Murray – Darling Basin Commission (MDBC) endorsed the strategy as a *River Management Plan* under Murray REP2 in September 1999. This means that the strategy must be taken into account along with the REP. It is particularly relevant to development applications for flood control works on the floodplain. The strategy shows areas of the floodplain, known as floodways, where these works will only be permitted if supported by a detailed assessment of impact showing that they are consistent with the planning principles of REP2. The *River Management Plan* also helps to streamline the approval process for these works outside the floodways by enabling multiple referrals to be handled simply.

DLWC has steered the strategy through a formal procedure, as set out by REP2, to make it into a *River Management Plan*. The strategy is consistent with the aims, objectives and principles of the REP. It has been through a public participation process including consultation with landholders and a public exhibition period from 17 February to 30 May 1997. Additionally, the strategy has been reviewed and supported as a *River Management Plan* by public authorities with interests in management of the floodplain. The public

authorities consulted during the development of the *River Management Plan* included:

- NSW Department of Urban Affairs and Planning
- NSW National Parks and Wildlife Service
- NSW Fisheries
- NSW Environment Protection Authority
- NSW State Forests
- Murray-Darling Basin Commission
- Wakool Shire Council
- Balranald Shire Council
- Swan Hill Rural City Council

2.3. Environmental Planning and Assessment Act

Where Development Consent is Required

"Controlled works" under *Part 8 of the Water Act (1912)* that are proposed for construction require development consent from the local council under Murray REP2. This procedure is under *Part 4 of the Environmental Planning and Assessment* (EPA) *Act, 1979*, and requires a broad environmental assessment of the works described in the development application.

Recent changes to the *EPA Act* under the Integrated Development Assessment reforms, link the development consent with associated licences, permits and approvals required by other legislation. This means that a licence for a work under *Part 8 of the Water Act* is now linked to the development consent for that work under Murray REP2. Under this system, the Development Application is referred to DLWC before consent is granted. DLWC advises the council as to whether it will grant in - principle approval. If Council grants development consent, it must impose conditions that are consistent with DLWC's "general terms of approval". If DLWC indicates that it will refuse approval, Council must refuse development consent.

Following the granting of consent, the applicant must formally obtain approval for the work under *Part 8 of the Water Act*. This would be issued as a matter of routine. The applicant has a 3–year period in which to obtain the approval.

Where Development Consent is not Required

A number of existing unlicensed banks, levees and works may have existing use rights, and may not require development consent. Such a work would have been constructed before the gazettal of Murray REP2 (31 March 1994), would have been lawful under planning instruments in place at the time; and would have remained unmodified since construction. All unlicensed works (regardless of existing use rights) require approval under *Part 8 of the Water*

Act. DLWC may require removal or modification of works where an approval under *Part 8 of the Water Act* is not in force.

If the controlled work does not require development consent, environmental assessment would still be required under *Part 5 of the EPA Act.* DLWC makes the decision as to whether or not the proposed work is likely to significantly affect the environment. DLWC's decision making is guided by *Clause 82 of the Environmental Planning and Assessment* (EPA) *Regulation, 1994* and the planning principles of Murray REP2. If DLWC determines that the work is likely to significantly affect the environment, then the applicant must prepare an Environmental Impact Statement (EIS) before any Part 8 approval is given. If DLWC determines that the work is not likely to significantly affect the environment, the application may be considered under *Part 8 of the Water Act*.

Environmental Assessment of the Strategy

The floodplain management strategy outlines a plan for the control of works that affect the distribution of floodwaters. It is not a direct proposal for work. It indicates areas of the floodplain where flood control works will only be permitted if supported by a detailed assessment of impact. As such, the strategy is neither a development nor an activity, and does not require a formal environmental assessment under the *EPA Act*. Because of the critical interactions between floodplain development and the floodplain environment, however, a comprehensive environmental assessment was considered to be a fundamental part of the strategy. Procedures similar to those required under *Part 5 of the EPA Act* were adopted in the absence of a formal structure for assessment. As part of this environmental assessment, the public authorities listed above (Section 2.2) were consulted to address areas of concern. The requirements of these agencies have been addressed in the strategy.

The environmental assessment in this strategy does not replace the need for environmental assessment when applications for development consent or licensing of specific works are made. An environmental assessment, as required under the *EPA Act*, will be undertaken when an application for works is received. The environmental assessment in this strategy will be used to assist in this assessment.

2.4. Other Legislative and Planning Controls

Other legislative and planning controls relevant to flood control works in the Stage IV area include:

- ***Wakool Local Environmental Plan (1992)***. It makes specific provisions regarding the construction of buildings or works on flood-liable land; the construction of levees on environmentally sensitive land; and the carrying out of development near rivers. Where inconsistencies exist between Wakool LEP and Murray REP2, the REP prevails to the extent of the

inconsistency. The REP does not, however, permit development that is prohibited by the LEP.

- The ***Rivers and Foreshore Improvement Act (1948)***. It requires a permit under *Section 3A* for any excavation in the bed and banks of a river or to within 40 metres of the banks of a river. This Act also has jurisdiction over earthworks that detrimentally affect the flow of water in a watercourse. It is administered by DLWC.

- The ***Fisheries Management Act (1994)***. It requires that NSW Fisheries be notified whenever any barrier to fish passage is constructed, altered or modified. The *Fish Habitat Protection Plan (1995)* is gazetted under this Act. It aims to provide protection for any habitat of fish "whether the habitat is critical for the survival of the species or required to maintain harvestable populations of fish".

- The ***National Parks and Wildlife Act (1974)***. The NSW National Parks and Wildlife Service (NPWS) is responsible for the protection and care of aboriginal relics (*Section 85*), the protection and care of native fauna (*Section 92*) and the protection of native plants (*Section 114*). The Act also allows for the establishment, preservation and management of areas of cultural, environmental and archaeological significance. It is an offence to knowingly destroy or disturb any Aboriginal site or relic in NSW.

- The ***Threatened Species Conservation Act (1995)***. It aims to conserve native plants and animals (including fish) threatened with extinction. The Act ensures that threatened species are taken into consideration during the planning process and in decision making by authorities. It protects not only threatened species, but also populations and ecological communities. The Act is administered by NPWS.

- The ***Protection of the Environment Operations Act (1997)***. This Act prohibits the pollution of waters unless it can be shown that the activities that caused the pollution were undertaken in accordance with either a regulation or the conditions of an environment protection licence. The Act can apply to pollution resulting from the construction of flood control works.

- The ***Forestry Act (1916)***. It places controls over the taking of timber, products or forest materials on Crown timber lands. These lands include State Forests and Crown lands over two hectares in area held under lease or licence. It is administered by NSW State Forests. Under the Act, NSW State Forests need to be notified if any trees are to be removed from Crown timber lands for the construction of flood control works.

- The ***Commonwealth Environment Protection and Biodiversity Conservation Act (2000)***. The Act will aim to ensure that actions likely to have a significant impact on matters of national environmental significance are subjected to a rigorous assessment and approval process.

Matters of national significance that may be relevant to Part 8 (Water Act) applications include Ramsar wetlands, nationally threatened species and ecological communities, and migratory species.

- The ***Native Vegetation Conservation Act*** **(1998)**. The Act provides a consistent approach to the sustainable management of native vegetation in NSW. It allows for partnerships between the community and government in developing controls on clearing at a regional level. The Western Riverina Vegetation Committee has been set up to prepare a Regional Vegetation Management Plan that includes the Edward - Wakool floodplain.

- ***State Environmental Planning Policy Number 44 - Koala Habitat Protection***. SEPP44 was gazetted in 1995. It aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas. The policy requires that councils listed under its schedule make specific considerations regarding koala habitat before granting consent to development applications. The policy applies to land in the Wakool local government area that is not dedicated or reserved under the *National Parks and Wildlife Act 1974* or dedicated as a flora reserve or State Forest under the *Forestry Act 1916*.

- **The *NSW Wetlands Management Policy*** (Department of Land and Water Conservation 1996). Adoption of this policy means that the Government, in its decision making, gives explicit consideration to the biophysical requirements of wetlands with the goal of ensuring their sustainable management.

- The ***NSW Biodiversity Strategy (1999)***. This strategy sets out a framework for coordinating and integrating government and community efforts in protecting the native biological diversity of NSW and in maintaining ecological processes and systems.

- The ***NSW Government Water Reform Process*** aims to ensure the long-term health of all waterways. Because the management of the Murray River and its anabranches is affected by agreements to meet water needs in Victoria, South Australia and New South Wales, water quality and river flow objectives will be set by interstate processes, which will include community consultation. Preliminary issues identified through community consultation include, among other matters, the need for a better approach to floodplain and levee management with regard to water flow, ecosystems and the control of harvesting water from the floodplain (NSW Government 1999).

2.5. Application Procedures

For the purposes of this report, "controlled works" as defined under the Water Act and "flood control works" as defined in Murray REP2 are collectively referred to as flood control works.

The floodway design outlined in this strategy does not represent an approval for the construction or alteration of flood control works or an approval for existing unlicensed flood control works. Approval for any proposed or existing unlicensed flood control works is required even if the works are outside the limits of the floodway.

As a first step in obtaining approval for existing works, landholders should enquire at the local council office as to whether or not development consent is required. A number of established banks that have not been altered since construction may have existing use rights and may not require development consent. If unlicensed, however, these banks will still require approval from DLWC under *Part 8 of the Water Act*.

Approval for flood control works is sought in the following way:

For works without existing use rights (development consent required):

A Development Application is made at the local council office for consent under Murray REP2.

An application is then lodged with the local DLWC office's Licensing Section for approval *under Part 8 of the Water Act.*

For works with existing use rights (development consent <u>not</u> required):

An application is lodged with the local DLWC office's Licensing Section for approval under *Part 8 of the Water Act*.

The approval process for flood control works is shown as a flow chart in Figure 3.

When development consent is required, a Development Application is lodged with the local council which is the consent authority for flood control works under Murray REP2. Council is required to refer the Development Application to DLWC before consent is granted. DLWC advises council of the environmental outcomes it expects from the development and this is attached to a condition of consent. If DLWC decides to refuse approval then Council must refuse development consent.

NPWS requires consultation where the development may affect a site of aboriginal cultural significance, a threatened species or land under its control. NSW Fisheries requires notification under the *Fisheries Management Act (1994).* The MDBC also requires consultation, as co-ordinator of the Interstate Levees Committee.

The Development Application for a flood control work is advertised in the local newspaper and any submissions are assessed by the local council or by its Floodplain Management Committee. Appeals against the council's development consent or refusal are heard in the Land and Environment Court.

Following the granting of consent, an application is lodged with DLWC for the issue of a licence under *Part 8 of the Water Act*.

When development consent is not required, an application is made directly to DLWC for approval under *Part 8 of the Water Act.* If the application meets DLWC requirements, which include environmental and planning requirements, it will be advertised in local newspapers and in the Government Gazette.

Any statutory authority or local landholder whose interests may be affected by the work may lodge an objection. If there are no objections, an approval will be granted.

When an objection has been raised, DLWC will interview all interested parties and try to resolve any matters in dispute. If the objection remains, the application is referred to the local Land Board for resolution. The Land Board is also referred to where an applicant objects to the proposed terms, conditions or limitations of an approval. Approvals under the *Water Act* are valid for a period of five years and require renewal after this period.

Note: The amendments to Part 8 (Section 2.1.1) will alter existing advertising and appeal procedures. If a work complies with an adopted floodplain management plan that has taken into account comment raised through a public exhibition, DLWC will not advertise the application. However, if the application does not comply with a floodplain management plan (or there is no floodplain management plan in place), the application will be advertised. If objections result following advertising, DLWC will arrange a compulsory mediation session with the purpose of resolving the objections.

DLWC determines an application by granting an approval or by refusing the approval. Appeals against DLWC's determination are heard in the Land and Environment Court.

3. CONCEPT OF THE STRATEGY

The floodplain management strategy presents a comprehensive floodway system that is intended to rationalise existing and proposed development on the floodplain. The basis of the strategy is to manage the flood risk by providing floodways with adequate capacity to enable the orderly passage of floodwaters across the floodplain while enabling the sustenance of floodplain ecosystems, wherever practicable. ***The system of floodways detailed in the strategy indicate areas of the floodplain where flood control works will not be permitted unless a detailed assessment of impact establishes that they are consistent with the planning principles of Murray REP2***. The construction of flood control works on the floodplain is subject to development consent under Murray REP2 and approval under the *Water Act (1912).*

The strategy identifies *hydraulically sensitive areas* where existing flood control works can significantly affect the behaviour and distribution of floodwaters. Where these areas include landholder - owned works, the strategy sets out a process of further consultation with a view to modifying the works to address hydraulic impacts. Where the *hydraulically sensitive areas* include government works such as roads or railway embankments the strategy makes specific directives to modify the works to address the hydraulic impact.

The strategy requires that Part 8 (*Water Act*) licence applications are lodged for all existing flood control works that are currently unlicensed.

3.1. Principles of Floodplain Management

The following principles were adopted in developing the floodway scheme presented in the strategy:

- the system of floodways should conform as closely as possible to the natural drainage pattern;
- floodways should discharge from a holding as close as possible to the location of natural flow paths;
- floodwater flows and depths should be as close as possible to the natural situation;
- natural floodplain water storage should be maintained, wherever feasible so that the flood wave is not unduly accelerated or increased in height as it moves downstream;
- the design of local drainage from protected areas to the floodways should be the responsibility of individual landholders;

- floodways should, where practicable, incorporate the needs of wetlands and other flood-dependent ecosystems;

- floodway design should take into account existing development, local and community concerns and the interests of key agencies; and

- floodway design should take into consideration the ***relevant planning principles of Murray REP2***, specifically with regard to:

♦ *Flooding -*

- the benefits to riverine ecosystems of periodic flooding;
- the redistributive effect of the proposed development on floodwater;
- the availability of other suitable land in the locality not liable to flooding;
- the availability of flood-free access for essential facilities and services;
- the pollution threat represented by any development in the event of a flood;
- the cumulative effect of the proposed development on the behaviour of floodwaters; and
- the cost of providing emergency services and replacing infrastructure in the event of a flood.

♦ *Land Degradation*

- development should seek to avoid land degradation processes such as erosion, native vegetation decline, pollution of ground or surface water, groundwater accession, salination and soil acidity, and adverse effects on the quality of terrestrial and aquatic habitats.

♦ *Landscape*

- measures should be taken to protect and enhance the riverine landscape by maintaining native vegetation along the riverbank and adjacent land, rehabilitating degraded sites, and stabilising and revegetating riverbanks with appropriate species.

♦ *Wetlands*

Land use and management decisions affecting wetlands should:
- provide for an hydrologic regime appropriate for the maintenance or restoration of the productive capacity of the wetland;
- consider the impact of surrounding land uses and incorporate measures such as a vegetated buffer which mitigates any adverse effects; and
- conserve native plants and animals.

♦ *Bank Disturbance*

- disturbance to the shape of the bank and riparian vegetation should be kept to a minimum in any development of riverfront land.

♦ *Water Quality*

- all decisions affecting the use or management of riverine land should seek to reduce pollution caused by salts and nutrients entering the River Murray and otherwise improve the quality of water in the River Murray.

3.2. Basis of Design

Generally, the floodway system has been designed to pass a flow of similar magnitude to the 1956 flood at a level no greater than the highest known flood level at any particular site. At a number of sites, however, it was not possible to meet this criterion. To pass the 1956 flood flow at these sites would have had a significant impact on existing development. Consequently, an alternative flood level above the highest recorded flood height was considered to be acceptable in some cases. The 1956 flood was chosen as the design flow since it has been the highest flood in the area this century and caused the most widespread disruption and damage. The 1956 flood flow has an Average Recurrence Interval (ARI) of about 100 years over most of the Stage IV area. This means there is a chance of about 1 in 100 that this flood flow could occur in any given year. While the floodway system has been designed to manage the flood risk for floods up to this magnitude, it is important to note that there is always the risk of more extreme floods occurring.

The design of the floodway was based on the above hydraulic criteria and considerations of the floodplain management principles listed in Section 3.1. Given the extent of development on the floodplain, it was often necessary to balance the protection of existing development against the needs of the floodplain environment. There are a number of cases where restoration of the natural pattern of flooding was not considered to be practicable because of economic impacts on landholders. Specifically, where the restoration of flooding was considered to be likely to impact on the security of a landholder's livelihood, then it was not considered to be practicable. Notwithstanding this, the strategy identifies former wetlands that lie outside the floodway as *areas of possible wetland value*. Options for the rehabilitation of these areas by returning flood flows will be explored when works affecting these areas are assessed for licensing purposes.

Locations where the design floodway does not conform to the natural drainage pattern are discussed in Section 6 (Hydraulic Assessment). *Areas of possible wetland value* and flood-dependent vegetation that could not practically be incorporated into the floodway system are discussed in detail in Section 8 (Environmental Assessment).

3.3. Hydraulically Sensitive Areas

Hydraulic assessment of the floodplain has determined that certain existing flood control works can significantly affect the behaviour and distribution of floodwaters. The strategy has included these works in special *hydraulically sensitive areas*.

Where these areas include government - owned works, the strategy makes specific directives to modify these works so that their hydraulic impact is addressed. These include the provision of additional waterway area across a number of roads and the removal of sections of the abandoned Stoney Crossing railway embankment.

Where *hydraulically sensitive areas* include privately owned works, DLWC will initially consult with the affected landholders regarding possible agreed options that will address hydraulic impact. If there is no agreed option available, the works will need to be modified according to DLWC's requirements unless the landholder can establish that the works do not have a significant hydraulic impact during floods. The landholder will also need to establish that the works are consistent with the planning principles of Murray REP2 (Section 3.1).

The *hydraulically sensitive area* classification will provide landholders with an opportunity to discuss and investigate possible structural options for their works that may address flooding impacts. Failure to comply with the procedure will result in DLWC contesting the works using the *Water Act*.

Note: Following the release of the draft strategy, DLWC has carried out further consultation with a number of landholders who have works in hydraulically sensitive areas. In some cases, agreed options that will address hydraulic impacts were identified. These included, for example, the partial removal of some supply channels and levee systems. These workable solutions are detailed in Section 7 of the strategy. The solutions will be implemented following the release of the strategy. Under Murray REP2 the alteration of flood control works requires a development consent from Council.

4. LAND USE

4.1. Development of Flood Control Works

European settlement of the Murray-Wakool-Edward floodplain began in the 1840s. Initially holdings were large, but were subdivided over time. By the mid-1950s, four irrigation districts were operating in the Central Murray region, including the Wakool Irrigation District near the eastern edge of the Stage IV area. Since then, the commercial success of rice growing has promoted the continuing growth of the region.

Accompanying this trend towards intensified farming practices, the increasing demand for farmable land led to the development of low-lying areas of the floodplain. Due to the flood-prone nature of this land, levees were constructed to protect crops and pastures. Additionally, development led to the construction of supply channels, roads and other works that have affected the distribution of floodwaters on the floodplain.

Levee Banks

Prior to the 1956 flood, there were relatively few levees in the Stage IV area. This flood caused widespread damage and disruption in the area. Subsequently, landholders started to construct levees on a large scale. More levees were constructed during the early 1970s when a series of floods occurred. As a result of this development, artificially high flood levels were observed during these floods.

Generally, levee construction has continued to increase in an uncontrolled and uncoordinated manner. At present, most properties in the Stage IV area have some form of levee network.

Supply Channels and Block Banks

River regulation has led to the construction of water supply channels on the floodplain. Although the works are not constructed to control flood flows, they are elevated and have an impact on the distribution of floodwaters. Supply channels in the study area are connected to the major streams, which are regulated to provide water allocations. These streams include the Wakool and Niemur Rivers as well as Merran, Coobool, St Helena, Mulligans, Larrys and Gum Creeks.

During periods of surplus flow, a number of landholders store off-allocation water for later use. This water is stored in wetlands or in stream channels by using block banks or flow regulators. A stream storage system has been constructed on an un-named creek that connects Coobool Creek to Gum Creek. Surplus flow from Coobool Creek is diverted into the creek and stored by means of two large block banks with pipes through them. This type of storage has the potential to affect the passage of flood flows.

Stoney Crossing Railway Line

Most of the original embankment of the Stoney Crossing railway line, which was closed in 1953, extends across the study area from Noorong Road to the Wakool River's Stoney Crossing (Figure 1). Although the embankment contains a number of waterway openings, it has a significant impact on the distribution and height of floodwaters.

The Stoney Crossing railway line was completed in 1928 and was part of a larger line that extended from Kerang in Victoria. The Stoney Crossing section of the line (from Murrabit to Stoney Crossing) was constructed to develop large holdings in NSW and to provide employment. The expected scale of development did not occur. Consequently, the railway became unprofitable and was closed.

Part of the embankment is presently used as a road. Wakool Shire Council maintains this five - kilometre section of the embankment from Fisher's Lane to Wetuppa Siding. The land resumed for the railway line is now held by the NSW Department of Public Works and Services.

Roads

The trend toward smaller holdings has increased the number of private access roads on the floodplain. Many of these have been elevated to provide access during floods. Consequently, they impede flood flows. Similarly, a number of council roads have been built up over the years. For example, MR 386 was raised in the vicinity of Coonamit Bridge following the floods of the 1970s.

4.2. Current Land Use

Current land uses include dryland and irrigated pasture development, and cattle and sheep grazing. Dryland and irrigated cereal (including rice) cultivation is a minor activity in the area.

Generally, irrigation is carried out in areas protected from flooding. Dryland cereal cropping and pasture development, on the other hand, are practised on flooded areas. Naunton (1995), in an economic assessment of floodplain management in the area, noted that dryland crops were risked on the floodplain partly because farmers wished to benefit from the higher soil moisture levels after flooding.

The village of Kyalite lies within the Stage IV area. Kyalite has a population of about 30 and is a service centre for the local area. The village is generally flood free.

5. NATURE OF FLOODING

5.1. Flood Behaviour

Figure 4 shows the creek and river system that contributes to flooding in the study area. Generally, flooding in the Murray and Wakool river system occurs in winter and spring. This flooding is primarily caused by rainfall from large atmospheric depressions that become stationary over the south - eastern corner of the continent. Such conditions are often compounded by spring snowmelt in the Australian Alps. Flood flows result from two separate sources in the Stage IV area:

- ***Edward River overflows downstream of Deniliquin which charge the Yallakool and Wakool Rivers.*** These flows originate in the headwaters of the Murray River and also the Victorian Ovens and Kiewa Rivers. Downstream of Tocumwal, flood flows leave the Murray via Tuppal and Bullatale Creeks and the effluent streams in the Millewa forest, including the Edward River offtake. All of these flows are concentrated in the Edward River at Deniliquin.

- ***Murray River breakouts between Echuca and Swan Hill***. These flows charge Thule, Barbers, Merran and Waddy Creeks, which in turn charge the Wakool River system in the study area. The flows originate in Victoria's Goulburn, Campaspe and Loddon Rivers, along with Murray River flows that do not enter the Edward River system. (These pass through the reach upstream of Echuca known as "The Choke").

The Wakool River is the main flood flow carrier in the study area. Merran Creek is also significant and charges a number of effluent streams that distribute floodwaters over the floodplain. These effluents include Coobool, St Helena, Mulligans and Larrys Creeks. Merran Creek and its effluents join the Wakool River at various points throughout the study area. During large floods, there is considerable interchange of flows across the floodplain between these effluent streams and the Wakool River, with the direction of flow dependent on the relative size of flows in the streams. Four other significant streams supplement Wakool River flood flows as they pass through the study area - Cunninyeuk Creek, Niemur River, Yarrein Creek and the Edward River. Niemur River and Cunninyeuk Creek flows charge Mallan Mallan Creek, which joins the Wakool River upstream of the Merran Creek junction. Wakool River flood flows join the Murray River at Wakool Junction, which is at the downstream end of the Stage IV area.

Billabong Creek, which emanates from a catchment to the north of Hume Dam and carries flows from the Murrumbidgee River via Yanco Creek, joins the Edward River at Moulamein. This creek has the potential to contribute significant flood flows to the Edward River and hence, to the study area.

Flood behaviour in the Central Murray region has been significantly modified following European settlement. Widespread construction (of levees, supply channels and roads) has resulted in the uncoordinated spread of floodwaters. A number of creeks have also been blocked to protect agricultural land. These include three of the Murray flood-runners between Echuca and Swan Hill - Bullockhide Creek, Old Waddy Creek and Snake Avenue; Lanker Creek, an anabranch of the Wakool River just upstream of the Stage IV area; and an un-named anabranch of Mallan Mallan Creek. Generally, agricultural development has led to a significant reduction in flood storage on the floodplain. This has resulted in a redistribution of floodwaters and an increase in flood levels throughout the Stage IV area.

5.2. Flooding History

Since records began, there have been a number of large flood events on the Central Murray-Wakool floodplain. The best available records of flooding in the Stage IV area are for the gauging stations on the Wakool River at Stoney Crossing and the Murray River below Wakool Junction. Records at both of these stations are extensive but do not include floods before the 1920s. A more comprehensive picture of historical floods in the study area is obtained by comparing recorded flows at relevant sites with longer term records. Table 5.1 shows ranked historical flood magnitudes for the stations in the study area, the Edward River at Deniliquin, and the Murray River at Echuca.

Table 5.1 Comparison of Recorded Historical Flood Magnitudes

Edward River Deniliquin		Murray River Echuca		Wakool River Stoney Crossing		Murray River d/s Wakool Junction	
Year	**Peak Flow**	**Year**	**Peak Flow**	**Year**	**Peak Flow**	**Year**	**Peak Flow**
1870	237,360	1870	171,000	1870	?	1870	?
1917	178,630	1867	134,000	1917	?	1917	?
1956	151,710	1916	111,000	1975	183,000	1956	228,000
1975	116,160	1975	108,300	1956	160,000*	1931	220,000
1889	116,000	1993	100,000	1931	123,300	1975	180,000
1931	111,830	1956	99,500	1993	104,000	1993	142,300
1955	107,420	1917	98,800	1939	90,400	1955	142,000
1993	84,100	1974	98,000	1974	90,060	1974	141,000
1939	78,300	1931	94,200	1981	83,200	1916	?
1973	78,060	1955	90,200	1973	78,200	1981	135,000
1981	75,960			1952	75,850	1973	133,000
1974	73,570			1955	72,700	1939	133,000
1916	65,000*						
(* Estimate)							

The 1870 flood was the largest recorded on the Edward River at Deniliquin and on the Murray at Echuca. Although Billabong Creek inflows were not recorded, it can be assumed that it was the largest flood event in the Stage IV area since European settlement. Other very large floods occurred in 1917 and 1956.

The 1956 flood is the largest in living memory in the study area. Even though higher flood flows were recorded at Stoney Crossing in the 1975 flood, the 1956 flood was of far greater volume and inundated large expanses of the floodplain for up to six months. Table 5.2 shows a comparison of peak flood levels and duration recorded at Stoney Crossing and gives an indication of relative flood volumes.

Table 5.2 Comparison of Peak Flood Heights and Duration on the Wakool River at Stoney Crossing

Year	Peak Gauge Height (m)	Flow (Ml/d)	Duration above 5.0m gauge height (days)
1975	10.09	183,000	98
1956	?	160,000	225
1931	?	123,300	126
1993	9.49	104,000	80
1981	9.07	83,200	63
1974	8.99	90,060	208
1939	8.96	90,400	102
1973	8.87	78,200	121
1955	?	72,700	105

Levee construction increased following the 1956 flood. As a result, later flood levels were artificially raised in the study area. Major events since include the 1974, 1975, 1981 and 1993 floods. A description of and comparison between these floods and the 1956 flood follows. Table 5.3 shows recorded peak flood flows at key stations on the Murray-Wakool-Edward floodplain.

TABLE 5.3 COMPARISON OF FLOWS FOR RECENT MAJOR FLOODS

RIVER	STATION	1956	1974	1975	1981	1993
		PEAK FLOW (ML/D)				
MURRAY	Yarrawonga	203,680	204,000 (May)	243,000	121,000	226,000
	Tocumwal	183,300	145,970 (Oct)	244,400	119,000	188,000
	Echuca	99,500	98,000 (Oct)	108,300		100,000
	Barham	34,820	32,150 (Oct)	34,220	33,700	33,100
	Swan Hill	31,050	32,800 (Oct)	34,500	32,900	33,300
	d/s Wakool Junction	228,000	141,600 (Nov)	180,000	135,200	142,200
KIEWA	Bandiana		49,600 (May)	32,300	24,700	30,900
OVENS	Wangaratta	76,000	146,800 (May)	89,000	108,600	187,100
GOULBURN	Shepparton	121,000	214,000 (May)	105,000	87,300	190,000
CAMPASPE	Rochester		57,000 (May)	49,700	20,500	20,700
LODDON	Kerang	4,020	3,420 (May)	5,650	3,380	4,060
EDWARD	Deniliquin	151,710	73,570 (Nov)	116,160	75,960	84,100
	Moulamein	35,700	24,300 (Oct)	17,300	17,500	14,700
WAKOOL	Gee Gee Bridge	75,600		53,800	51,000	53,600
	Coonamit Bridge		58,900 (Nov)	114,500		101,000
	Stoney Crossing	160,000	90,060 (Nov)	183,000	83,200	104,000
	Kyalite	189,900				119,000
WADDY CK	Tumbledown Bridge				6,800	5,600
MERRAN CK	u/s Junction		4,300 (Nov)	7,100		5,500
CUNNINYEUK CK	Cunninyeuk Road Bridge	15,500				18,100
NIEMUR	Mallan School	24,500		22,100		21,500

5.2.1. 1956 Flood

The 1956 flood followed a large 1955 spring flood and exceptionally high runoff over the summer of 1955-56. The flood was characterised by high flows in the Upper Murray River, all of the Victorian tributaries and Billabong Creek.

Rainfall in March 1956 in north - eastern Victoria and southern NSW was generally 50 per cent above average. The Upper Ovens Valley received more than three times the average in April. Above average rainfall continued to occur over the Murray River catchment in subsequent months. This rainfall resulted in record inflow to Hume Reservoir in April, May and July. At the beginning of April, Hume Reservoir was 831,000 Megalitres (Ml) below its full supply level, however, this airspace was rapidly exhausted and overflow commenced on 5 May 1956.

There were some minor flood peaks on the Murray River at Albury during April and May 1956. Heavy rain at the end of June and early July produced two further peaks, nine days apart. The second of these peaks coincided with the maximum peak for the year in the Ovens River. The peak flood discharge at Albury in 1956 of 110,830 Ml/d was considerably lower than the peaks recorded in 1870, 1917 and 1931. Nevertheless, the total volume discharged past Albury during the flood exceeded that of the 1931 flood and approached that of the 1917 flood.

The combined Ovens and Murray flows produced a peak flood flow (189,600 Ml/d) on the Murray River at Tocumwal on 11 July 1956. The Goulburn River at Shepparton had reached a peak flow of 121,000 Ml/d on the previous day. This is the fifth highest flow on record - remarkably high given that the newly constructed Eildon Reservoir mitigated a significant component of the flood flows.

The Murray River at Torrumbarry Weir rose to 7.80 metres at the end of May 1956. It did not vary more than 0.03 metres from this level until it began to fall in early November. Similarly, the Murray River at Swan Hill remained within 0.10 metres of its flood peak from late July through early September. Floodwaters from the Loddon River caused a flood peak at Swan Hill of 4.67 metres (31,035 Ml/d) in mid-August.

At Deniliquin, the Edward River reached a peak flow of 151,700 Ml/d. Levees on the northern side of town were deliberately breached to relieve the concentration of floodwaters in the main channel. The high flood level was partly due to the influence of the Goulburn River since the very high flows in that river tended to hold up the Murray above Echuca. This forced the Murray floodwaters down the Edward River and other upstream effluents.

Flooding was widespread downstream of Deniliquin. A large proportion of the area bounded by the Murray River in the south and the Edward River in the north was inundated. Although levee development on the floodplain was not extensive at the time of the flood, most levees in this area were breached. The Edward River at Moulamein exceeded any previously recorded flood height. This was partly because of the contribution from the Murrumbidgee River via Yanco Creek and Billabong Creek which carried a peak flow of 20,060 Ml/d at Bundy.

The 1956 flood was of very high volume and caused extensive inundation in the study area. The multiple flood peaks that occurred on the Murray River at Tocumwal and the Goulburn River at Shepparton, were absorbed by the large flood storage of the Edward-Wakool floodplain. Consequently, the Murray River downstream of Wakool Junction rose steadily to a peak of 228,000 Ml/d.

5.2.2. 1974 Flood

Flooding occurred on the Murray-Edward-Wakool floodplain in both May and October 1974. The May flood resulted from heavy rainfall over the catchments of the Victorian tributaries, whereas the October flood was generated from more widespread rainfall and was the larger event upstream of the Ovens River confluence.

Widespread flooding occurred in the Ovens, Kiewa, Goulburn and Campaspe Rivers in May 1974. This flood ranked first or second largest in all of these catchments. Consequently, the May flood was the larger of the two 1974 flood events in the Murray reach from Yarrawonga to Tocumwal. Due to its relatively low volume, however, the flood peak was substantially attenuated downstream where the October flood reached higher levels along the Murray River. Edward River flows were relatively minor during both floods, with a peak of 73,570 Ml/d (ranked 12th) recorded during the October flood at Deniliquin. Farther downstream, this flood was boosted by flows from Billabong Creek which was charged by flooding in the Murrumbidgee Valley. The October 1974 flood was the larger of the two 1974 flood events in the Stage IV area.

5.2.3. 1975 Flood

The flood of October 1975 resulted mainly from heavy rainfall in the upper reaches of the Murray and Ovens Rivers. Significant flooding also occurred on the Goulburn River, with some minor flooding on the Loddon and Campaspe Rivers. At Albury, a flow of 199,000 Ml/d was recorded and this flood ranked third highest on record after the 1870 and 1917 events. This ranking was maintained along the Murray River as far downstream as Tocumwal. Farther downstream, the relative magnitude of the 1975 flood reduced, even though tributary inflows were high. Nevertheless, the 1975

flood still ranks as the fifth largest on record at Swan Hill, where a peak of 4.78m (34,500 Ml/d) was reached.

Murray River overflows downstream of Tocumwal produced substantial flood flows in the Edward River at Deniliquin during the 1975 event. A flow of 116,160 Ml/d was registered. It was the fourth highest on record. The high flows, combined with flood breakouts from the Murray River between Echuca and Barham, produced major flooding in the Stage IV area. The 1975 peak flood flow on the Wakool River at Stoney Crossing (183,000 Ml/d) is the highest on record. Downstream of Coonamit Bridge flows were attenuated since inflows from Billabong Creek, which charges the lower Edward River, were relatively minor during this flood.

5.2.4. 1981 Flood

Heavy rainfall occurred during July and August 1981 in the catchments of the Upper Murray, Ovens, Kiewa and Goulburn Rivers. Hume and Dartmouth Dams mitigated significant volumes of runoff from the Upper Murray catchments, and a relatively moderate flood flow at Albury (82,300 Ml/d) resulted. Flood flows in the Victorian tributaries, however, particularly the Ovens and Goulburn Rivers, were substantial. The combination of these flows produced significant flooding in the Stage IV area.

At Deniliquin, flooding produced by effluents of the Murray River downstream of Tocumwal was relatively moderate (75,960 Ml/d) and as a result, Edward River breakouts into the Wakool River system were not major. Flood flows in the Goulburn River at Shepparton, however, were very high (approaching those of 1956) and caused major outflows from the Murray River into Thule and Barbers Creeks. The flows passed into the Wakool River and combined with substantial inflows from Waddy and Merran Creeks to produce major flooding at the upstream end of the Stage IV area near Noorong Road.

Downstream at Stoney Crossing and Wakool Junction, flood flows were smaller relative to the other recent large floods. This was due to the relatively minor contribution of the Edward River and its effluent streams, the Niemur River, and Cunninyeuk and Yarrein Creeks. The duration of the flood in the study area was relatively minor as can be seen from Table 5.2.

5.2.5. 1993 Flood

During October 1993, high intensity rainfall occurred in the catchments of the Victorian tributaries. Severe flooding in northeastern Victoria resulted. Rural flood damage was widespread. A number of towns in the Ovens, Kiewa and Goulburn catchments were badly affected by floodwaters. Flood flows in the Ovens River at Wangaratta were the highest recorded this

century (190,000 Ml/d). A record flood flow occurred in the Goulburn River at Benalla. The peak flow at Shepparton (190,000 Ml/d) was substantial, despite the significant mitigating effects of Lake Eildon. These flows, combined with significant flows in the Kiewa, Campaspe and Loddon Rivers, produced major flooding in the Stage IV area.

Murray River effluent flows downstream of Tocumwal produced a flood flow of 84,100 Ml/d in the Edward River at Deniliquin. Downstream, breakouts from the Edward River contributed to Wakool River flows that were then surcharged by overflows from the Murray River between Echuca and Barham. These overflows were substantial and a combined peak flow of 43,840 Ml/d was gauged in Thule, Barbers, Cow and Calf Creeks.

Major flooding occurred along the Wakool River and all of the streams in the area between Gee Gee and Coonamit Bridges. Widespread inundation of agricultural land resulted from levee breaches on Mulligans Creek, Merran Creek, St Helena Creek and the Wakool River. Contribution to Edward River flows from Billabong Creek was negligible since there was no flooding in the Murrumbidgee Valley. Consequently, flood flows in the Edward River downstream of Moulamein were relatively minor and did not significantly supplement Wakool River flows which attenuated downstream of Coonamit Bridge.

Heavy rainfall over the Stage IV area in early October contributed to flooding problems. Rainwater was often impounded on the landward side of levees.

5.3. Comparison of Flood Levels in the Study Area

This section will give a brief description of the comparative levels reached by various floods over the study area. It is important to clarify that higher levels reached in a particular area do not always signify that the particular flood event was larger. This is particularly so if development has taken place in the floodplain over time.

When comparing the magnitude of various floods, the best way to gain a true appreciation of the respective magnitudes is to compare the hydrographs of each flood. The definition of a hydrograph is a graph that shows how the discharge at any particular location changes with time during a flood. The definition of discharge is the rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second. Discharge is a measure of how much water is moving and is different to the speed or velocity of flow, which is a measure of how fast the water is moving (for example, metres per second).

The preceding section showed how a large catchment upstream of the Stage IV area can produce a variety of rainfall runoff combinations that in turn,

produce different hydrographs for particular flood events. Each hydrograph can contain different peak flow discharges, volumes and times of duration of flood events.

Section 5.2 outlined the size of a number of flood events. For example, it was clear that the 1956 flood event in the study area was much larger than the 1993 flood. Notwithstanding this, the flood level reached by the 1993 flood was higher in a few locations than the flood levels reached during the 1956 flood. This indicates that there have been significant changes to the floodplain in particular areas.

5.3.1. General

Obtaining accurate information to compare historical flood levels is sometimes difficult where no official gauge readings have been recorded. During the study, the clearest comparisons were possible in instances where landholders had marked flood levels on tree trunks. Flood comparisons were also made based on landholders' recollections of flood levels relative to fence posts, sheds or other structures, with a reasonable degree of accuracy. Providing that the landholder witnessed the particular event (and was not relying on hearsay), previous flood levels could be readily compared to the recent 1993 flood since peak marks were still clearly shown on tree trunks and farm structures.

The following comparison of flood levels in the study area is restricted to the 1956, 1975 and 1993 floods which were three of the largest events of the past 50 years. Records of these floods are also the most reliable and extensive available for the study area.

5.3.2. Gee Gee Bridge (Noorong Road) to Coonamit Bridge (MR 386)

A comparison was made between 1993 and 1975 flood levels in this reach. It showed that the 1993 flood levels in the Gee Gee Bridge area were 0.1 metres lower than the level reached during the 1975 flood. Within the area adjacent to "Oberon" (Findlay, D. M.), the 1993 flood level was in the order of 0.2 metres higher than the 1975 flood level. Downstream of this area through to Coonamit Bridge, the 1993 flood level was generally 0.2 metres lower than the 1975 flood level.

A summary of comparative levels (including some 1956 flood level comparisons) follows:

- At Gee Gee Bridge, the 1975 flood level was 0.1 metres higher than the 1993 flood level.

- At the Coobool causeway, the 1975 flood level was 0.2 metres higher than the 1993 flood level.

- At the Waddy Creek offtake area, the 1975 flood level was 0.08 metres higher than the 1993 flood level.

- Adjacent to "Mooronga" (Howard, C.), the 1993 and 1975 flood levels were similar.

- The flood peak in Mulligans Creek adjacent to "Moira Park" (Thoolan, H) was 0.01 metres higher in 1975 than it was in 1993; the 1974 flood level was 0.19 metres lower than in 1975.

- The flood level of Mulligans Creek near "Burnside" (Ady, S.) was 0.08 metres higher in 1993 than it was in 1975.

- The flood level of Mulligans Creek at "Wetuppa" (Cox, G.S.) was slightly higher in 1993 than it was in 1975. The peak level of 1975 was also higher than it was in 1956.

- At "Wahroonga" (Chilvers, F.G.), the Wakool River flood level adjacent to the island area was 0.08 metres lower in 1993 than in 1975. The 1975 and 1956 flood levels were similar in this area.

- The 1993 flood level in the Wakool River adjacent to "Oberon" (Findlay, D.M.) was 0.2 metres higher than in 1975. The 1993 flood level was 0.23 metres higher than the 1956 flood level.

- The 1993 flood level was 0.04 metres higher than in 1956 in the Coobool Creek area adjacent to "Wyena" (Bryan, A.D.) It was also 0.03 metres higher than the 1975 flood level.

- At Merran Creek adjacent to "Karinga Park" (Dunn, R.J. & V.T.), the 1975 flood level was 0.46 metres higher than the 1993 flood level, and 0.28 metres higher than the 1974 flood level.

- The 1975 flood level on the Wakool River adjacent to C.V. Hayes' property was 0.23 metres higher than it was in 1993. The 1956 flood level was similar to the 1975 flood level.

- At B.P. & D.F. Farrell's property, the 1975 flood level was 0.15 metres higher than the 1993 flood level, and 0.25 metres higher than the 1981 flood level. The 1975 flood level was also higher than the 1956 level in this area.

- The 1975 Wakool River flood level adjacent to Coobool Island was 0.2 metres higher than the 1993 flood level.

- At Coonamit Bridge, the 1975 flood level was 0.21 metres higher than the 1993 flood level, and the 1975 flood level was 0.75 metres higher than the 1956 flood level.

5.3.3. Coonamit Bridge (MR 386) to Wakool/Murray River Junction

The 1993 flood levels in this area are significantly lower compared to the 1975 and 1956 flood levels.

- The Wakool River flood levels, adjacent to "Liewa" (Martha Guy Pty Ltd) were generally 0.25 metres higher in 1975 compared to 1993.

- Measured on the left bank immediately upstream of Kyalite Bridge, at “Riverside” (Hammond, W.), the 1956 flood level was 0.49 metres higher than the 1975 flood level. It was also 0.98 metres higher than the 1993 flood level.

- On “Rosenhoe” (Standen, B.) in the area downstream of Kyalite Bridge, the 1956 flood level was 0.23 metres higher than the 1975 flood level, and 0.43 metres higher than the 1993 level.

5.4. Costs and Benefits of Flooding

The floodplain of the Stage IV area contains extensive agricultural development as well as ecologically important areas including large stands of riverine woodland and a substantial number of biologically productive wetlands. The impact of flooding in this environment generates a range of costs and benefits.

Costs

Floods can be potentially devastating to property and the local economy in the developed areas of the floodplain. Flooding can incur significant costs by causing damage to crops, livestock and other private property as well as to public roads and bridges. These costs are borne by the landholders and the local community. Natural disaster funding to flood victims is a cost to the whole community.

Naunton (1995) identified a series of costs incurred by the landholder as a result of flood damage on private land. His study was based on a survey of farmers affected by flooding on the Wakool, Niemur and Edward Rivers. Landholder costs identified included:

- *Reduced gross margins* from rice, other cereals and grazing

- *Flood management costs* including the relocation of pumps, the patrolling of levees and moving of livestock

- *Costs to rectify flood damage* including the repair of levees and fences, increased fence depreciation, increased weed control on flooded areas and the resowing of pasture

- *Opportunity costs* including changes in crop rotations that reduced the area of rice or dryland cereals sown and reductions in the number of livestock carried as a result of flooding. These also include the cost of reduced management performance of farms during floods. This occurs when farmers are distracted from ongoing management and direct their resources into flood management and mitigation. Additional opportunity costs are incurred when farmers are unable to pursue their normal off-farm income generating activities during floods.

The uncontrolled development of flood control works on the floodplain has the potential to increase the risk of flood damage locally by detrimentally affecting the distribution of floodwaters. Further, this type of development can increase flood damages upstream by artificially raising flood heights, and downstream by accelerating the flood wave.

Benefits

Flooding is a natural process. It is of fundamental importance to the lower Edward-Wakool floodplain's ecology. It produces a number of environmental benefits by supporting the breeding and development of native animals, plants and aquatic life. Flooding also increases soil moisture and contributes silt and nutrients to floodplain soils. This process helps to restrict levels of nutrients and sediment in the main streams, thereby enhancing water quality. Flooding further enhances water quality by flushing saline deposits from wetlands and watercourses.

Flooding can generate a range of economic benefits. It replenishes soils and can enhance summer cropping opportunities. It increases the potential for economically important fisheries. By sustaining floodplain ecosystems, there is potential for eco-tourism and other recreational activities. Generally, however, the value of flooding to floodplain ecosystems is difficult to quantify in economic terms. Without flooding, environmental damage to the floodplain would be substantial, resulting in loss of biological productivity, species abundance and diversity, and degradation of soils and water quality.

6. HYDRAULIC ASSESSMENT

6.1. General

An hydraulic assessment was carried out to determine the floodway width required to pass the 1956 flood as explained at Section 3.2.

The initial stage of the assessment involved the collection of flood data and the mapping of flood control works. Flood data was collected by researching flood histories; interviewing landholders; and monitoring the 1993 flood in the study area. Cross-sectional surveys of the floodplain were carried out and design flood flow distributions were determined. Hydraulic calculations were then applied to size the floodway.

6.2. Landholder Consultation

All available landholders in the Stage IV area were interviewed during the formulation of the floodplain management strategy. They were consulted to determine the flood levels and behaviour of past floods, to identify current flooding issues and to map existing flood control works on the floodplain. Additionally, DLWC has undertaken further consultation with some landholders to discuss possible outcomes to modify works in *hydraulically sensitive areas*. Landholders with wetlands identified in the draft strategy as being outside the floodway have also been consulted to discuss aspects of wetland management.

6.3. Swan Hill Regional Flood Strategy

The MDBC is currently co-ordinating a flood strategy for the Swan Hill region. The strategy aims to manage the flood risk along the Murray River and its floodplain from Barham to the Wakool Junction. It also aims to ensure that cultural activities within the region are compatible with the requirements of the floodplain environment. Sinclair Knight Merz has been preparing the strategy in consultation with the community, local councils, regional water authorities, and Victorian and NSW water, conservation and planning authorities. Community responses to a report outlining the completion phase for the strategy are currently being considered. Ultimately, preferred measures in the strategy would be adopted in floodplain management plans in NSW and Victoria.

As part of the overall strategy, Lawson and Treloar (1995) prepared an hydraulic evaluation of flood strategies. This report provides the base information for a wide range of flood management options as well as an understanding of the likely impact of these options. Further to this report, there has been extensive community consultation. At present, measures recommended in the strategy for delivery of flood flows into NSW upstream

of Swan Hill are consistent with the Stage IV strategy outcomes. If this situation changes following community input, the Stage IV strategy will be reviewed accordingly.

6.4. Flood Flow Distribution

As stated earlier, the distribution of floodwater that occurred during the 1956 flood provides the basis for the design of the floodplain management scheme. This distribution is shown in Figure 5. The distribution of flows for the October 1993 flood is shown in Figure 6.

Design discharges were adjusted so that flows at the downstream end broadly matched the sum of the inflows to the Stage IV area. This flow balance took into account the relative timing of inflows and flow attenuation over the floodplain. As well, design discharges were adjusted throughout the study area at each point where a significant inflow or outflow from each of the main streams occurred. The design value of 11,900 Ml/d adopted for the Waddy Creek inflow was obtained from *Swan Hill Regional Flood Strategy - Hydraulic Evaluation of Strategies (Lawson & Treloar 1995).*

6.5. 1993 Flood Monitoring

The 1993 Murray River flood, which occurred shortly after work commenced on the strategy, provided an ideal opportunity to obtain accurate data for hydraulic analysis of the floodplain. Consequently, the following information was gathered during the 1993 flood:

- stream gaugings
- flood levels
- flood slopes
- vertical and oblique aerial photography
- satellite imagery

The stream gaugings were planned for the purpose of determining flow distributions throughout the study area. The 1993 flow distribution information was also used to estimate 1956 flood flows in areas where these values were unknown. Flow gaugings were taken at key sites on each of the major streams. Flows across Noorong Road and through the openings under the dismantled railway line were also measured.

Peak flood levels throughout the study area were marked and later levelled as part of general floodplain surveys. Flood slopes were obtained by recording a series of flood levels along each stream.

Oblique and vertical aerial photography of the flood was taken at a scale of 1:25,000. A mosaic of the vertical photography was put together and this proved to be very useful during discussions with landholders. (The photo-

mosaic is also available in slide format.) An aerial video of the flood was recorded at the same time.

Satellite tracking was carried out and SPOT satellite imagery of the flood was obtained on computer tape. This imagery can be viewed at various scales and with different enhancements. Additionally, 1:100,000 scale prints of SPOT and Landsat images taken at two different stages of the flood were purchased. These prints show the progress of the flood through the study area and have been useful during discussions with landholders. The SPOT image is shown in Figure 7.

DLWC officers undertook extensive boat trips throughout the study area to observe flood flow patterns during the flood.

6.6. Hydraulic Analysis

Cross sectional surveys included the major flow obstructions within the study area. These obstructions include levees and channel banks, block banks and roads. When an obstruction was surveyed, the surveyors also included the adjacent natural surface. This information enabled the effect of the obstruction on flood levels to be determined by hydraulic modelling.

Modelling was carried out by applying Manning's formula. It equates discharge with the hydraulic characteristics of the cross section at a given water level. Initially, the formula was calibrated to the 1993 flood at each cross section, using known flood levels and flow values. The 1956 flood flows were then applied to each cross section and the increase in flood level noted. Each cross section was then modified so that the increased floodway could pass the 1956 flood discharge at levels that approximated the highest known flood levels at the site.

At some locations, it was impossible to keep to the above criteria and convey the 1956 flood discharge at a level no higher than the highest known flood level. Doing so would have significantly impacted on existing development. As a result, a compromise value above the highest recorded flood level was considered acceptable in some cases. Estimates were based on engineering judgement in places where flood levels were not known.

Modelling showed that, in most cases, significant changes to existing obstructions were needed to provide adequate floodway capacity.

6.7. Concept of Flood Storage

The natural dampening effect that floodplain storage has on flood behaviour makes it necessary to retain, where possible, the maximum amount of pondage on the floodplain. This ensures that the flood wave is not unduly accelerated or increased in height as it passes downstream.

This principle was applied during the development of guidelines for the Stage I to III areas. As a result, consideration was given not only to the hydraulic ability of the floodways to carry flood flows, but also to the effect the schemes would have on flooding at downstream locations.

The concept of floodplain storage has also been applied to the Stage IV strategy. Wherever practicable, the spread of floodwaters into floodplain storage areas has been incorporated into the scheme. Examples of floodplain storage include wetlands such as lakes, billabongs and swamps; and off-route low-lying land. The provision of flooding to these areas not only reduces the flood wave but also enables wetland ecosystems to be sustained. Large floodways also assist in ensuring that the flood wave is not unduly accelerated or increased in height as it passes downstream.

6.8. Limited Height Levees

It has not been possible to recommend maximum flood protection in a number of developed areas of the floodplain since this would adversely affect flows during major flood periods, such as the 1956 event. Nevertheless, because of the extent of development and the lack of other suitable flood-free land on these properties, it was considered essential to recommend as much flood protection as possible. It is recommended that levees protecting these areas are limited in height to the 1993 flood level. Larger floods would cause inundation and allow the area above the limited height levee to convey additional flood flows. The newly inundated area would also then contribute to flood storage.

Based on a flood frequency analysis for the Wakool River at Stoney Crossing, it is expected that flows larger than 20 year ARI would overtop the limited height levees. Stoney Crossing provides the best estimate of flood frequency for the 1993 flood in the study area since it is the only gauging station with a continuous and extensive streamflow record (74 years). It is also located in the floodplain area that underwent major flooding in 1993, being upstream of the Edward River confluence. The frequency of the 1993 flood flow would vary within this floodplain area, but would be expected to be in the order of 20 year ARI.

Except for a small ring levee that is recommended to protect a landholder's house, levees currently protecting the areas in question will need lowering to meet the level of the 1993 flood. Although many of the affected areas were inundated during the 1993 flood, this resulted from the failure of levees rather than overtopping.

Following inundation, it would be expected that flows would be returned from the limited height levee areas to the river system as soon as possible so that flood damage is minimised. The levees would be manually breached at

their downstream ends when the river level had fallen sufficiently to allow drainage.

The use of the limited height levee option is consistent with the following planning principles of Murray REP2 regarding flooding:

- the hazard risk of developing flood-prone land;
- the availability of other suitable land in the locality not liable to flooding;
- the redistributive effect of development on floodwater; and
- the cumulative effect of development on the behaviour of floodwaters.

It is important to note, however, that limiting the height of some existing levees will continue to restrict flooding to particular wetlands. This is not consistent with the planning principles of Murray REP2 regarding wetlands and land degradation. This aspect of limited height levees is discussed in detail in Section 8 (Environmental Assessment).

6.9. Access During Flood Periods

The concept of providing access to properties situated within the floodplain was considered during the developmentof the strategy. It was not possible, however, to recommend any practical forms of access during the passage of a major flood event. The construction of access roads across a floodplain or the retention of existing obstructing access roads will, in the majority of cases, adversely affect flood flows.

7. FLOODWAY DESIGN

7.1. General

Before this study, there was little or no coordination of structures on the floodplain. The net result has been a situation where flood patterns have been considerably altered and smaller magnitude floods have caused the flood height to increase.

Property owners who have been affected by floodwaters have, in many cases, either constructed levees or increased the height of existing levees when a flood subsides. Some landholders have hastily constructed levees at the onset of a flood. This has, in turn, forced neighbours to raise their levees or construct new ones to protect their own properties, creating an intensifying cycle of bank construction.

The altered pattern of flooding resulting from these activities, along with channel works, road and rail construction works and storage blockbank activity, has in some cases caused an overload of available floodway capacity. This has resulted in increased flood heights and velocities and has led to instances of levee failure.

Rational floodplain management involves the careful integration of floodways with protected areas so that all landholders gain some advantage, but not to the detriment of others. It is essential that development follows a coordinated plan so that the piecemeal development of the past is corrected and not repeated in the future.

As a basic requirement, any scheme must incorporate the principle of providing floodways that possess adequate hydraulic capacity and continuity to enable the orderly passage of floodwater throughout the entire system. With this in mind, the scheme is based on restoring as far as possible, the efficient conveyance of flood flows.

It became evident during the floodplain analysis that a number of works will have potentially adverse hydraulic impacts during floods. These works are likely to need modification or removal to mitigate their impacts on adjoining or even remote properties. The strategy has identified these works and has included them in *hydraulically sensitive areas*. The strategy outlines specific requirements for modifying government - owned works in these areas. The strategy sets out a process for further consultation and investigation of privately owned works in *hydraulically sensitive areas* (Section 3.3).

7.2. Detailed Scheme

The following section discusses the design floodway in detail. The generalised network of floodways within the area covered by this report is shown in Figure 8 (at rear).

For the purposes of this report, the total area has been divided into five sub-areas selected for the presentation of plans, and to achieve some continuity of the drainage pattern within an area. The subdivision is shown in Figure 8.

The following chapters include a discussion of the *hydraulically sensitive areas* determined from the analysis. Further, some existing levees have been given special height restrictions to provide reasonable flood protection and to allow overtopping during the design flood. Other levees will require raising to avoid overtopping (refer to Section A.5). DLWC will provide landholders with observed flood height information at or near these sites to establish levee heights that incorporate a reasonable clearance for freeboard. Specific heights will be recommended in most locations.

Table 7.1 outlines the *hydraulically sensitive areas*, required modifications to publicly - owned flood control works, the limited height levee areas and other structural recommendations. The *hydraulically sensitive areas* are shown on Figures 9 to13.

It is important to note that the order of accuracy in determining floodway size depends on the quantity and quality of basic data. Future floods will be monitored so that any potential inaccuracies in the scheme layout can be corrected.

7.2.1. SUB-AREA A

This Sub-Area is shown on Figure 9 and extends from Noorong Road to an area about 16 kilometres downstream, through the floodplain. It includes the Wakool River floodplain approximately to the confluence with the Jaffrey Creek anabranch, along with the Merran Creek floodplain to the Waddy Creek junction. Sub-Area A also contains the floodplains of Mulligans and St Helena Creeks as well as most of the Coobool Creek floodplain.

A.1 Noorong Road

The Stage II guidelines provided details relating to the waterway requirements for the area up to and including Noorong Road. The report indicated causeway widths and waterway requirements that would be required to pass the design flood.

The report also stated that the suggested changes to the road designs were preliminary only. They were based on the idea of allowing a shallow flow of water across the road during major floods. This would allow the road to remain trafficable. The lengths of causeways quoted were included to highlight the extent of works required to pass the design flood and were indicative only. The final form of any works to be carried out will be subject to the outcome of discussions with Wakool Shire Council and the Roads and Traffic Authority.

The Stage IV report agrees with the recommendations of the Stage II guidelines for Noorong Road. The upstream portion of the Stage IV strategy is a continuation of the downstream limits of the Stage II guidelines. The floodway designed for the area downstream of Noorong Road will provide a continuous conveyance for flood flows from the Stage II area into the Stage IV area.

An extract from the Stage II report is outlined below and has been included for convenience:

> "It is understood that major reconstruction of Noorong Road is proposed across the Wakool River floodplain. As mentioned previously, it is recommended that appropriate additional waterway area be incorporated in the Gee Gee area to convey the additional flows generated by the closure of the Lanker-Noorong-Armstrongs Creeks system. This will ensure landholders to the south of the Wakool River are not disadvantaged by the closure of this system.
>
> A total causeway length of 1100 m (set 0.3 m below the 1975 flood level), in addition to the existing bridges, is required to pass the design flow between the Gee Gee Approach Bridge and the Wakool

River No 3 Bridge. This will ensure that flood levels are not increased beyond the record levels of 1975.

To promote a more efficient flow through the Wakool River No 3 Bridge in Noorong Road, the levee on "Glenesk" blocking the flood runner "feeding" this bridge should be removed to natural surface. The remainder of the levee on "Glenesk" obstructing flows between the Wakool River No 2 and No 3 Bridges should be restricted in height to less than the level of the proposed causeways to be constructed in the trunk road. This will provide protection to the area enclosed by the levee in minor floods, but will ensure the levee does not obstruct the passage of floodwaters moving towards the causeways in major floods.

With the additional area mentioned above taken into account, more than half of the flow crossing Noorong Road will cross between the Gee Gee Approach Bridge and the Wakool River No 3 Bridge.

To the south west of the Wakool River No 3 Bridge is St Helena Creek. While St Helena Creek is an effluent of Merran Creek, during a major flood most of the flow along St Helena Creek would be contributed by breakaway flows from the Wakool River.

To enable the design flow to pass Noorong Road in the vicinity of St Helena Creek, a causeway 600 m in length (set 0.3 m below the 1975 flood level) is required in addition to the existing bridge waterways. Causeway lengths of 150 m and 450 m should be located to the north of St Helena Creek and between the intersection of Noorong Road with Narcurrie Road South and the start of the levee on "Merran Dale" respectively. To enable flows to reach the proposed causeway to the south - west of this intersection, a causeway 450 m long (set 0.3 m below the 1975 flood level) will be required in Narcurrie Road South between Noorong Road and the Merran anabranch creek. This is the first watercourse crossed to the south of Noorong Road along Narcurrie Road South.

The levee and supply channel on "Glenesk" between St Helena Creek and Narcurrie Road South should be restricted in height to less than the level of the proposed causeways to be constructed in Noorong Road. This will provide protection to the area behind the levees in minor floods, but will ensure the banks do not obstruct the passage of major floodwaters moving towards the causeways.

To pass the design flow on Merran Creek across Narcurrie Road South a total of 1100 m of causeway (set 0.3 m below the 1975 flood level) is required. This causeway is additional to the existing bridge waterway area. 800 m of this causeway would be adjacent to the

Merran Creek bridge and 300 m adjacent to the anabranch bridge. Additional causeway requirements for St Helena Creek (mentioned above) increase the length of the causeway in the vicinity of the anabranch bridge to a total of 750 m.

To convey the design flow along Merran Creek a floodway with a minimum width of 500 m is required, and to convey the design flow along anabranch creek a floodway with a minimum width of 250 m is required. This will require the levees along these creeks to be re-aligned.

The existing road bridge in Noorong Road over Merran Creek does not require augmentation to enable it to pass the design flow. However the old road formation upstream of the present bridge is an obstruction and should be removed.

The Coobool Creek causeway in Noorong Road requires an additional 800 m of causeway (set 0.3 m below the 1975 flood level) to pass the design flow in that area."

As stated above, this strategy supports the recommendations of the Stage II report for the floodplain immediately upstream of the Stage IV area. Since Noorong Road forms an interface between the two study areas, the sections of the road identified as obstructing flood flows, have been included in *hydraulically sensitive areas* in the Stage IV strategy.

The flood flow downstream of Noorong Road is conveyed via three main flood flow components. These include:

- the combined Merran and Coobool floodway,
- Mulligans Creek; and
- the combined St Helena, Wakool River, Wyam Creek floodway.

As shown in Figure 6, the main flood flow is conveyed in the combined St Helena, Wakool River and Wyam Creek floodway. Each of the three flood flow components is discussed below:

A.2 Combined Coobool Creek and Merran Creek Floodways

Just downstream of the proposed enlarged Coobool causeway (additional 800-metre causeway), the existing waterway is not adequate and has been included in an *hydraulically sensitive area*. It will be necessary to provide an opening of 400 metres in the existing abandoned railway embankment to pass the design flow as shown in Figure 9.

The Merran Creek component of the combined floodway is conveyed from upstream of Noorong Road via the waterway, through the abandoned Stoney Crossing Railway, and then through the Noorong Road crossing (situated

adjacent to Fishers Lane). These waterway areas are adequate and no modification of these two bridges is suggested.

The combined Coobool Creek-Merran Creek floodway then continues to proceed jointly in a north - westerly direction until the flood flow is split into separate flows. The Merran Creek floodway conveys flows in a westerly direction from the Fountains Road bridge area. The Coobool Creek floodway conveys the flood flows in a northerly direction.

A.2.1 Coobool Creek Floodway

The railway embankment in the area west of the Wetuppa Reserve will significantly impede the design Coobool Creek flood flow. This section of the railway bank has been included in an *hydraulically sensitive area*. It will be necessary to reduce the railway embankment to natural surface over a distance of 400 metres in addition to the existing two bridge structures (Figure 9).

Passing through the area downstream of the abandoned railway line, Coobool floodwaters are constricted and obstructed from freely entering the Wakool River floodplain by levee development protecting the properties owned by D.P. Bryan, A.D. Bryan, K.M. Cummings, D. Findlay and D. J. & R. J. Fulton. This levee development forms a ringed levee around the properties, providing an island form of protection during floods. A creek crossing on the road leading to the above properties also obstructs Coobool floodwaters.

There were a number of options available for providing orderly conveyance of the Coobool flood flows into the Wakool River floodplain. The best practical compromise is to allow the island area to be protected by a limited height levee. The hydraulic analysis revealed that if the levee was limited to 1993 flood level protection only, flows exceeding the 1993 flood event would cause the ringed levee area to be inundated. The area above the 1993 level of protection would then be available to assist in the conveyance of larger floods. The impact of larger floods on properties adjacent and upstream of the ringed levee would be reduced in this way. The limited height levee will provide some protection to the leveed area, but will ensure the banks will not obstruct the passage of major floods moving towards the Wakool River. The implementation of the limited height levee would allow the design Coobool Creek flood flows to rejoin the Wakool River flood flows. A smaller portion of the Coobool flood flow would be conveyed via the Tally's Lake floodway. To further reduce the constriction of Coobool flood flows, the road crossing Coobool Creek near A.D. Bryan’s house should be lowered to low flow level.

During the 1993 flood, floodwaters breached the north - eastern portion of the ringed levee. This resulted in floodwaters virtually inundating the entire

ringed levee area. The area has been inundated during past floods and the majority of the north - eastern portion of the levee was hastily constructed prior to the onset of the 1993 flood event.

It is recommended that the optional 300 metres-wide floodway, shown in Figure 9, which will significantly assist in the conveyance of Coobool Creek floodwaters to the Wakool floodplain, be implemented. Maximum protection to the residential properties situated within the subject area is available and is also shown in Figure 9. The alternative option would be to provide a 600 metre-wide floodway extending from the left bank of Coobool Creek adjacent to A.D. Bryan's homestead. The 600 metres-wide floodway would, however, significantly impact on the properties owned by K.M. Cummings, A.D. Bryan and D.P. Bryan. It would also impact on their current farming practices.

The road that crosses the inflow creek to Tallys Lake (Box Creek) constricts flood flows and is included in an *hydraulically sensitive area*. Additional waterway will need to be provided at this road crossing, along with the necessary remedial work at the lake exit area as shown in Figure 9. The exit flows from Tally's Lake then re-enter the combined Coobool Creek-Wakool River floodplain.

A.2.2 Merran Creek Floodway to Waddy Creek Junction

The Merran Creek floodplain separates from the combined Merran and Coobool floodplain, extending west from the Merran Creek bridge crossing at Fountains Road.

Two *hydraulically sensitive areas*, where flood control works can have a significant impact on the distribution and behaviour of the design flood, have been identified along this reach:

- Works on land owned by A.N. & J.W.D. Fountain, J.H. Nixon, R.J.Dunn and B. & G. Basile, have been included in an *hydraulically sensitive area* (Figure 9).
- Road approaches at Officers Road in the area south of the Merran Creek Bridge Crossing. A causeway of about 250 metres will be required to pass the design flows.

A.3 Mulligans Creek floodway

Mulligans Creek conveys flows from its origin as an offtake from St Helena Creek through the western portion of the Mulligans Plains area, to its junction with Larry's Creek.

During the 1993 flood, the flood flow through Mulligans Creek was gauged at 2794 Ml/d. The flood level during the 1993 event was about 0.01 metres

lower than the 1975 flood levels at the upstream portion of the Mulligans Plain area. The 1993 flood level at the downstream portion of the Mulligans Plains area was reported to be 0.08 metres higher than the 1975 flood level.

The Mulligans Plain area, currently protected by levee works, was inundated during the 1956 and 1975 floods. During the 1993 flood, responsive action taken by landholders in urgently restoring a breach that occurred on the northern portion of the Mulligans Plain levee, prevented the Mulligans Plains area from being totally inundated.

The leveed Mulligans Plains area isolates an extensive area of floodplain and has the potential to significantly constrict major flood flows. For this reason, only partial protection of the Mulligans Plains area to the 1993 flood level is recommended. Floods of larger magnitudes than the 1993 flood would inundate the protected area.

The analysis has shown that a floodway width of 200 metres from the upstream portion of the Mulligans Plains area through to its junction with Larrys Creek, would be required to convey the design flow. Works on land owned by H. Thoolan and S. Ady have been included in an *hydraulically sensitive area* (Figure 9).

A levee bank on the western part of G. Cox's property potentially obstructs flood flows along the creek and has been included in an *hydraulically sensitive area.*

Immediately downstream, a section of the access road leading to D. J. & R. J. Fulton's property encroaches into the design floodway and has been included in an *hydraulically sensitive area*.

The levee situated at the northern portion of the property "Burnside" (Ady, S.) has also been included in an *hydraulically sensitive area* since it prevents the interchange of flows between Mulligans Creek and the St Helena-Wakool floodplain (Figure 9). Removal of this levee would re-establish the interchange and provide relief for both systems, depending on the timing of Merran Creek and Wakool River flows.

A.4 St. Helena Creek

St Helena Creek is an effluent of Merran Creek. Its origin is at the St Helena regulator, situated upstream of Noorong Road. Downstream of Noorong Road, the creek is situated on the eastern side of Mulligans Plains and re-enters the Wakool River via G.S. Cox's property.

While St Helena Creek is an effluent of Merran Creek, during a major flood most of the flood flow along St Helena Creek would originate from breakaway flows from the Wakool River. As mentioned earlier in the Stage

II extract, it will be necessary to provide a 600 metre-long causeway additional to the existing bridge. This will enable the design flow to pass Noorong Road in the vicinity of St Helena Creek.

From the area downstream of Noorong Road to the property "Mooronga" (Howard, C.), the St Helena flood flows continue to interact and merge with the Wakool River flood flows. A smaller portion flows in the direction of Mulligans Creek.

The St Helena Creek flood flow through C. Howard's property is confined by levees on the eastern portion of Mulligans Plains, as well as the levee and channel works in the area opposite C. Howard's dwelling. The major obstruction to the St Helena flood flows is the raised portion of the access road as shown in Figure 9. This portion of the access road is likely to increase flood levels in St Helena Creek upstream of the access road and has been included in an *hydraulically sensitive area*.

Subject to appropriate approval, a levee that provides maximum protection may be built on the land surrounding C. Howard's dwelling as shown in Figure 9. The area on the eastern portion of St Helena Creek opposite the dwelling area should be protected to 1993 flood height only as shown in Figure 9.

A.5 Wakool River downstream of Noorong Road

Relating to Noorong Road, the Stage II report accounted for the closure of the Lanker-Noorong-Armstrong Creek system by incorporating an additional waterway in the Gee Gee Bridge area.

Downstream of Noorong Road, combined Wakool River-Wyam Creek flood flows travel in a north westerly direction until reaching F.G. Chilvers' island levee. The flood flow is then divided. The combined Wakool and St Helena flood flows pass to the west of the island levee area, while the Wyam floodplain conveys flood flows to the east. This is shown in Figure 9.

The passage of floods across the Wakool-St Helena floodplain is significantly restricted by supply channels and a portion of the levee on the eastern part of "Wetuppa" (Cox, G.S.). Flows are also restricted by a levee near the south - eastern boundary of the property. These works have been included in *hydraulically sensitive areas* (Figure 9). Following consultation with the landholder, a workable solution is available to alleviate flow constriction by the supply channels. The two straight sections at the outermost ends of the channel system nearest to the floodway limit can be lowered to ground level to allow flows to pass through. Similarly, the small levee near the south - eastern boundary can be lowered to natural surface.

Downstream of the above restricted area, the Wakool River and Wyam Creek floodplains recombine and travel generally in a northerly direction. The western portion of this floodplain contains the ringed levee protection area owned by D.P. Bryan, A.D. Bryan, K.M. Cummings, D. Findlay and D. J. & R. J. Fulton. Comments relating to this ringed levee area were outlined in Section A.2.1. Landholders in the protected ring levee area have been offered protection up to the 1993 level of flooding. They now take up a portion of the active floodplain area. Consequently, it will be necessary for the levees on the adjacent eastern portion of the Wakool floodplain (properties owned by D. Nalder, C. & D. Nalder and G. Biggs) to have a crest level of at least 0.3 metres above the 1993 flood level. This will allow the design flow to be adequately conveyed.

Immediately downstream, limited height protection may be provided to the small portion of ringed levee on DP. Bryan's eastern property boundary. The levees situated in this area and the upstream section of the supply channel on properties owned by D.P. Bryan, C. & J. Hayes and D. Uebergang have been included as *an hydraulically sensitive area* (Figure 10). Further assessment has determined that the downstream parallel sections of the supply channel do not significantly obstruct flood flows. This section has not been included in the *hydraulically sensitive area.*

The levee situated on the eastern boundary of "Wyena" (Bryan, A.D.) obstructs Wakool River flood flows entering the downstream reach of Larry's Creek. This levee has been included as an *hydraulically sensitive area*.

The area immediately downstream of the ringed levee contains water supply block banks situated at Gum Creek and Coobool Creek, along with a number of un-named creeks as shown in Figures 9 and 10. The block banks are used to store off-allocation water as outlined in Section 4.1. The high level of these banks blocks almost all of the inbank creek flow during flood periods. Although the block banks do not impede a major proportion of the design flood flow, they are not desirable hydraulically since they restrict the passage of minor to moderate floods along the creeks. For this reason, it is recommended that the crests of the block banks be lowered to maximum irrigation levels only. As well as their impact on flood flows, block banks also have environmental impacts including the blocking of fish passage. The block banks will be subject to environmental assessment as part licensing renewals or application under the *Water Act*.

7.2.2. SUB-AREA B

This Sub-Area is shown on Figure 10 and extends from the downstream limits of Area A (Figure 9). The upstream properties situated in Area B include those of D. Uebergang, C. & J. Hayes, and D. Nalder. This Sub-Area primarily includes the Wakool and Coobool Creek floodplains to the area

just downstream of Coonamit Bridge. It also includes the inflow areas of Cunninyeuk Creek and the Niemur River.

B.1 Cunninyeuk Creek outlet flows

The floodplain guidelines for Cunninyeuk Creek immediately upstream of the Wakool River floodplain are outlined in the Edward-Niemur Rivers Floodplain Development - Stage III report (Department of Water Resources 1989). The area downstream of Cunninyeuk road is covered in the present report.

Downstream of Cunninyeuk Road, flows that exit Cunninyeuk Creek and enter the Wakool floodplain are restricted by levees on “Glenbar” (Nalder, G.). These levees have been included in an *hydraulically sensitive area* (Figure 10).

B.2 Niemur River outlet flows

Apart from the modifications outlined in the Stage III guidelines report, there are no recommended Stage IV works required along the Niemur River downstream of Cunninyeuk Road.

B.3 Lower Coobool Creek Floodplain

This portion of the Coobool floodplain extends from the upstream boundary of D. Uebergang’s property to the Coobool Creek and Wakool River junction (which is situated in the property owned by the Coobool Island Pastoral Company).

Within the property owned by D. Uebergang, maximum protection surrounding the dwelling is recommended as shown in Figure 10. The portion of the Coobool Road that is situated on this property has been included in an *hydraulically sensitive area*. The road should be lowered to natural surface between the area indicated in Figure 10. Raising the road level in this area could adversely impact on the level of flooding at both residential dwellings on D. Uebergang’s property as well as the residence on Coobool Island Pastoral Company’s property.

Maximum protection surrounding the "Maronda" dwelling and adjacent shed is recommended on Coobool Island Pastoral Company’s property, subject to appropriate approval. Also subject to appropriate approval, the existing supply channel adjacent to “Maronda” may remain. The area north of “Maronda” near Coobool Road should retain levee protection to the 1993 flood level as shown in Figure 10. Flood flows larger than the 1993 flood event will cause the area to be inundated. The area above the 1993 level of protection would then be available to assist in the conveyance of larger floods. During the 1993 flood, this area was inundated largely because the

levees were constructed hastily at the onset of the flood. A breach subsequently occurred. The reason for permitting a limited height levee in this area is due to the extent of the floodplain to the east.

The Coobool Island Pastoral Company property also contains block banks that are used for water storage. The block banks are similar to the block banks in Sub-Area A and impede minor to moderate floods. For this reason, it is recommended that the block banks be set to maximum supply level only. As well as their impact on flood flows, block banks also have environmental impacts including the blocking of fish passage. The banks will be subjected to an environmental assessment as part of any licensing application or renewal under the *Water Act*.

B.4 Wakool River downstream of Area A

The Wakool floodplain in the upstream part of Area B (see Figure 10) consists of the Wakool River and Coobool Creek floodwaters, and the Cunninyeuk flood flows.

Maximum flood protection is recommended surrounding the landholder's dwelling on the property owned by C. & J. Hayes as well as a small area to the north of the homestead. The location of the two areas is shown in Figure 10. Because of the isolation of this property during floods, the small area of available protection to the north of the homestead was considered necessary for stock refuge purposes. The width of the floodplain in this area is about 10 kilometres. The levees will not, therefore, constrict flood flows.

A similar form of protection is offered at the adjacent property owned by B. Farrell, where maximum protection of the homestead and a small area for stock refuge is recommended. The stock refuge site is situated on higher ground that is currently prone to some flooding. These recommendations are shown in Figure 10.

Downstream of B. Farrell's property, the Wakool floodplain combines and interacts with flood flows from Cunninyeuk Creek and the Niemur River. They interact in turn with Coobool Creek floodwaters in their western Coobool Island passage. A portion of the combined Wakool, Niemur and Cunninyeuk Creek floodwaters is also conveyed past the eastern and northern portion of Coobool Island via the Pissen and Mallan Mallan Creek system.

Subject to appropriate approval, the Coobool Island area may be protected against floodwaters. This is shown in Figure 10. The partly completed levee system situated to the east of the island, however, restricts the conveyance of flood flows and has been included in an *hydraulically sensitive area*. Also, the levee on the southern bank of Mallan Mallan Creek restricts flood flows

across the northern part of Coobool Island and has been included in an *hydraulically sensitive area*.

Downstream of Coobool Island, the Wakool floodplain is constricted by the levees situated on "St Elmo" (Sheldrick, M.) on the left bank area, just upstream of Coonamit Bridge. Accordingly, these levees have been included in an *hydraulically sensitive area* (Figure 10). During the 1993 flood, a break formed in the northern portion of this levee system causing the protected area to be inundated.

The Coonamit Bridge area has been a cause of contention for landholders situated upstream of the bridge area. The majority of landholders claim that the Coonamit Bridge area is a major flow restriction and acts to adversely affect many upstream properties. Following hydraulic analysis, the road approaches to the bridge have been included in an *hydraulically sensitive area*. An additional waterway area of about 300 square metres will be required on the MR 386 approaches to both Coonamit Bridge and Mackenzies Creek. Some of this waterway area was provided by two additional bridge openings constructed in 1997. Causeways will be required to provide the remaining waterway area. Details of the additional waterway requirements will need to be discussed with Wakool Shire Council. Safety aspects will be an important consideration in these discussions, given the curved nature of the MR 386 road approaches near Coonamit Bridge.

7.2.3. SUB-AREA C

Sub-Area C is shown in Figure 11 and extends from the area immediately downstream of Coonamit Bridge through to Kyalite Bridge. It includes a major part of the lower Wakool River floodplain and the lower reaches of both the Yarrein Creek and the Edward River floodplains, downstream of the Stage III limits. The downstream limits of the Merran Creek system are also included in this section.

C.1 Yarrein Creek outlet flows

During the course of the Stage IV study, it was considered necessary to alter the downstream limit of the Stage III guidelines along Yarrein Creek. This was done in order to incorporate a high level flood runner situated between the northern bank of Yarrein Creek and the southern bank of the Edward River. The previous downstream limit of the Stage III guidelines was 18 kilometres upstream of the confluence of Yarrein Creek with the Wakool River. Following the above amendment, this limit is now 27 kilometres upstream of the confluence. The Stage IV floodplain management strategy includes the Yarrein Creek floodplain downstream of the Stage III limit.

The recommended floodway for the lower Yarrein Creek area is shown in Figure 11. Floodwaters at the downstream limits of the Yarrein Creek

floodplain intermix with the Wakool River floodplain. There are no recommended Stage IV works on the downstream portion of the Yarrein Creek floodplain.

C.2 Edward River outlet flows

As outlined in Section C.1, the modification that was made to the downstream limit of the Stage III guidelines on Yarrein Creek also applies to the southern bank of the Edward River. Consequently, the Stage IV area has been extended upstream and now includes the last 32 kilometres of the Edward River floodplain. The recommended floodway for this area is shown in Figure 11.

With regard to the northern boundary of the Edward River, the Stage III report stated that floodplain management guidelines for this area will need to be formulated in conjunction with a future Billabong Creek investigation. This also applies to the remaining downstream portion of the Edward River situated in the Stage IV area. The floodplain adjacent to the southern bank of the Edward River is unobstructed between the downstream limits of the Stage III study through to its junction with the Wakool River.

C.3 Merran Creek outlet flows

Twenty kilometres (approximately) downstream of Coonamit Bridge, the Merran Creek flood flows enter the Wakool floodplain from the left bank floodplain area. A supply channel on land owned by A.D. & J.W. Pollard restricts the exit of Merran Creek flood flows and has been included in an *hydraulically sensitive area* (Figure 11). Following consultation with the landholder, a workable solution to address the flow restriction has been reached. This involves lowering the downstream section of the channel (about one kilometre) to natural surface and leaving the upstream section intact. Also in this area, a section of the abandoned railway line situated on the right bank of Merran Creek has been included in an *hydraulically sensitive area*. This section of the line will need to be removed to natural surface over a distance of 400 metres (Figure 11).

C.4 Wakool River downstream of Coonamit Bridge

Immediately downstream of Coonamit Bridge, the Wakool floodplain is confined by levee works situated on both banks. A portion of the levee on the right bank consists of a raised access road extending between the homestead on “Scotsburn” (Kaylock, R.) and the homestead owned by M. Guy Pty Ltd. These works have the potential to significantly affect flood flow behaviour and have been included in an *hydraulically sensitive area* (Figure 11). Ringed levee protection is recommended at the homestead situated on the property owned by M. Guy Pty Ltd.

From Coonamit Bridge to Kyalite Bridge, the Wakool floodplain expands in width and is relatively unobstructed. Nevertheless, the supply channel situated on the left bank of the floodplain on "Mascotte" (Tippett, J.) has the potential to constrict flood flows and has been included in an *hydraulically sensitive area* (Figure 11). Following consultation with the landholder, a workable solution to address the flow constriction has been reached. This involves making two openings in the channel where identified low points in the topography occur. These openings would allow flood flows to pass across the structure. There is high ground upstream and downstream of the remainder of the channel.

Immediately downstream of this area, Bingera Creek, an effluent stream which carried flood flows from the Wakool to the Murray has been blocked at the Stoney Crossing Road, at the Tooleybuc - Kyalite Road and at other sites downstream. The creek is shown on Figure 8. It has been blocked for many years to protect development along its course, including the village of Goodnight. Blockages on the creek held during the 1956 flood. Since the Wakool floodway has been designed to convey the 1956 flood flow, it accounts for the blockage of Bingera Creek. There is little evidence of a channel at the upstream end of the creek. Although agricultural development is likely to have altered some of the former flow paths, it is probable that flows breaking out of the Wakool passed overland as sheet flow until they were concentrated by changing topography. The creek starts to become well defined at a distance of about five kilometres from its source. At its downstream end the creek is used to hold water extracted from the Murray for irrigation.

The channel and levee works situated on the right bank in the area just upstream of Kyalite Bridge are likely to add to flooding on the adjacent left bank area. These works, on land owned by Kyalite Pistachios, have been included in an *hydraulically sensitive area* (Figure 11).

7.2.4. SUB-AREA D

Sub-Area D extends from the downstream side of Kyalite Bridge to the area just downstream of the Murray-Wakool River junction. Area D is shown in Figure 12.

D.1 Wakool River downstream of Kyalite Bridge

Downstream of Kyalite Bridge, the Wakool floodplain expands in width and flood flows are conveyed to the Murray River junction via the Wakool River floodplain and the Wee Wee Creek anabranch.

A portion of the supply channel situated on the left bank area downstream of Kyalite Bridge can constrict flood flows. This channel, which is within the property owned by C. Prater, has been included in an *hydraulically sensitive area* (Figure 12). Following a submission by the landholder, a workable solution is available to address the flow constriction. Three sections of the channel at low points can be lowered to ground level to allow flows to pass through and around the structure. The remaining sections of the channel are on relatively high ground.

The northern portion of the supply channel situated in the area upstream of "Tralee" (Standen, J.) has also been included in an *hydraulically sensitive area* and will be subject to further analysis. Although a large proportion of this channel is situated on higher ground, the northern portion is likely to significantly reduce the available floodplain width in this area. High level flood protection can be offered by the supply channel and levee works to the south of the subject supply channel. Downstream of these works, the floodway is largely unobstructed to the Murray River junction.

The Stage IV floodplain management study was initially designed to extend downstream to the Murray-Wakool River junction. During the investigation phase of the study, however, it was considered necessary to extend the study downstream of the junction to include levee works situated on "Windomal" (Dalton, G.W.) and "Woodmount" (Howley, L.E.). These works have the potential to significantly impede the passage of the design flood and have been included in an *hydraulically sensitive area* (Figure 12).

7.2.5. SUB-AREA E

Sub-Area E covers the Merran Creek floodplain from Merran and Waddy Creeks' junction to the confluence of Merran Creek with the Wakool River. Sub-Area E also includes Waddy Creek from the Murray River offtake to its confluence with Merran Creek.

The major portion of Sub-Area E is shown in Figure 13. This portion includes the Merran Creek floodplain from the junction of Merran and Waddy Creeks to an area of the Merran Creek floodplain situated about three kilometres upstream of the Wakool River junction. The remaining downstream section of the Merran Creek floodplain is shown in Figure 11. The Waddy Creek area is shown in Figure 9.

E.1 Waddy Creek floodway

Lawson and Treloar (1995), in their hydraulic study for the Swan Hill Regional Flood Strategy, discuss the impact of opening a number of presently blocked effluents that would convey flood flows from the Murray River upstream of Swan Hill into the Merran Creek system. Effluents such as the presently blocked Bullockhide system, Old Waddy Creek and Snake Avenue were discussed in combination with the existing Waddy Creek effluent.

The recommendations of the Stage IV strategy have been based on the use of only the Waddy Creek effluent to convey flood flows from the Murray River near Swan Hill. This strategy has not incorporated options for the re-opening of the currently blocked effluents. If a flood occurs on the Loddon River along with extended duration high flows on the Murray, the Waddy Creek effluent will be the available conveyor of flood flows into the Merran Creek system. The Waddy Creek effluent will operate for the duration of the Loddon River flood. As mentioned previously (Section 6.3) if a decision is made in future to re-open any of the blocked effluents, the strategy will be reviewed accordingly.

The hydraulic analysis of the Waddy Creek flood flows revealed that the existing waterway is inadequate and will require enlarging in order to convey design flood flows. It is currently confined by levees and some supply channel works. These banks are located on properties owned by I. Martin, K. Moar and G. & C. Basile and have been included in an *hydraulically sensitive area* (Figure 9). The recommended floodway width at the upstream portion of the Waddy Creek floodway is 650 metres tapering down to 500 metres in the area upstream of Tumbledown Waddy Bridge. Downstream of the bridge to the junction of the Merran Creek, the recommended floodway width will need to taper from 500 metres to 300 metres as shown in Figure 9.

E.2 Merran Creek downstream of Waddy Creek Junction

The hydraulic analysis has shown that, downstream of the Waddy Creek junction, the existing Merran Creek floodway requires widening at a number of locations to pass the design flood. Existing levees and supply channels can impede flows in the design floodway at a number of locations. These banks have been included in *hydraulically sensitive areas*. The banks are listed below:

- Levees situated on the properties owned by G. & C. Basile, G.M. & I.H. Seton-Stewart, and A. & N.M. Pinney in the area one kilometre downstream of the Waddy - Merran Creek junction (Figure 9).

- Levees situated on the left bank of Merran Creek on G. Foote's property, seven kilometres downstream of the Waddy Creek junction

(Figure 9). These levees are adjacent to the area where offtake flows occur into the Lake Tooim area.

- The levee and old channel works situated just downstream of the Lake Tooim offtake area on land owned by North Star Park Nominees & Coonawarra Enterprises Pty Ltd. (Figure 13). Following consultation with the landholders, a workable solution to remove the banks is available.

- The levee and channel banks on the left bank of Merran Creek, adjacent to the Coobool Siding Road (Figure 9). The levee is situated on the upstream side of the road on the property owned by North Star Park Nominees & Coonawarra Enterprises Pty Ltd. The channel banks are on the property owned by G.Moore. Following consultation with the landholder, a workable solution to address flow constriction caused by the channel banks has been reached. This involves lowering the section of channel perpendicular to the flow to natural surface.

- The portion of the levee bank situated on the left bank of Merran Creek in the area immediately upstream of MR 386 on “Studley Park” (T. Vallance). This is shown in Figure 13. After consultation with the landholder, a workable solution has been reached. The levee bank can be modified so that its shape is streamlined relative to the direction of flood flows.

A small levee bank at the upstream end of the wetland known locally as "Coobool Swamp", prevents high level flood flows from entering the *area of possible wetland value* referred to in Section 8.2.6 of this report as Un-named Wetland 11. Naturally, this area would have filled from Merran Creek flows at its upstream end and drained back to Merran Creek at its downstream end. The area has been cleared and is currently under cultivation. MR 386 crosses the centre of the area and a series of pipes passes water under the road. An active floodway through Un-named Wetland 11 has not been included in the strategy for the following reasons:

- The design flood flow has been concentrated in the Merran Creek area and incorporates the "Coobool Swamp area".

- The natural inflow point into Un-named Wetland 11 is at a relatively high flood level.

- It will be possible to avoid additional expenditure on the portion of MR 386 that crosses Un-named Wetland 11.

- The lower portion of the Un-named Wetland 11 area is situated on “Moallack” owned by H. Bourchier. The owner is prepared to accept en-route flood storage waters. This is conditional, however, upon limited height backwater protection being provided for floods up to

the five - year return period. The request is reasonable and has been incorporated in the strategy as shown in Figure 13.

E.2.1 Lake Tooim block bank

The block bank that is situated at the entrance to Lake Tooim as shown in Figure 13, is currently removed during the onset of flooding and re-installed after filling of the lake occurs. This process does not prevent the lake from acting as an en-route storage area and assists in attenuating flood flows. Consideration should be given, however, to the design of an automatically operated structure as the current method of bank removal and reinstallation is inefficient. A modified structure would be subject to an environmental clearance. Lake Tooim is also discussed in Section 8.2.6 of this report.

E.2.2 Merran Creek downstream of MR 386

The supply channel on the left bank of Merran Creek just downstream of the MR 386 creek crossing extends into the design floodway and is likely to constrict flood flows. Accordingly, the channel has been included in an *hydraulically sensitive area*. The channel is situated on property owned by H. Bourchier as shown in Figure 13.

The section of Merran Creek floodplain in the area between two kilometres and seven kilometres downstream of the MR 386 crossing consists of a large basin. A description of the basin is provided in Section 8.2.6 under the sub-heading *Un-named Wetland 12*. The eastern portion of this basin has been developed for agricultural production and consists of an extensive irrigation layout and associated levee works. The western portion of the basin also contains some irrigation works. The majority of the western part of the basin is owned by H. Bourchier. He is willing to allow large floods to inundate his portion of the basin to improve soil conditions, but wishes to retain a limited form of protection against floods smaller than the five-year return period flood. The request is reasonable and has been incorporated in the strategy.

There are a number of levees and channel banks encroaching into the design floodway in the area of the basin. These banks are situated on properties owned by M. Sheldrick, H. Bourchier, J.D. & J. Williams and H.J. Jager. The banks have been included in an *hydraulically sensitive area* (Figure 13).

TABLE 7.1
SCHEDULE OF HYDRAULICALLY SENSITIVE AREAS AND REQUIRED MODIFICATIONS

LANDHOLDER/ COMPANY/ PROPERTY NAME	FIG. NO	AREA NO	DETAILS
Wakool Shire Council / RTA	9	A	• Provide additional causeways of 1100 metres length to pass the design flow between the Gee Gee Approach Bridge and Wakool No. 3 Bridge (*Hydraulically sensitive area*). • Provide additional causeway of 600 metres length to pass flows across Noorong Road near St Helena Creek (*Hydraulically sensitive area*). • Extend the existing Coobool Creek causeway on Noorong Road by 800 metres length to pass the design flow (*Hydraulically sensitive area*). • Causeways are to be constructed at 0.3 metres below the 1975 peak flood level.
E.J. Howard *"Mooronga"*	9	A	• Land surrounding house may contain maximum protection levee.
	9		• Land near St. Helena Creek (on eastern side) to be protected to 1993 flood height only as shown by hatched lines in Figure 9.
	9		• Road approach impedes St Helena Creek flood flows - included in *hydraulically sensitive area*.
H.Thoolan *"Moira Park"*	9	A	• The Mulligans Plain area to be protected to 1993 flood height as shown by hatched lines in Figure 9.

LANDHOLDER/ COMPANY/ PROPERTY NAME	FIG. NO	AREA NO	DETAILS
S. Ady *"Burnside"*	9		• Levee on the north - eastern corner of Ady's property, currently separates the creek and river floodwaters, included in *hydraulically sensitive area*.
NSW Public Works and Services	9	A	• Remove abandoned railway to natural surface over 400 metres in the area just downstream of Coobool causeway *(Hydraulically sensitive area).*
G.S. Cox *"Wetuppa"*	9	A	• Levee on right overbank area near Wetuppa reserve included in *hydraulically sensitive area*. • Workable solution available for supply channel system near Wakool River and levee bank near S. Ady's boundary (Section 7.2.1 A.5).
D. J & R. J. Fulton *"Glenmore"* D. Findlay *"Oberon"*	9	A	• Access road level from Wetuppa Reserve to Larrys Creek included in *hydraulically sensitive area*.
K.M. Cummings *"Ming Park"* A.D. Bryan	9		• Provide high level flood protection in the area surrounding dwellings.
"Wyena" D.P. Bryan	9		• The levee providing island protection to the properties owned by D. J. & R. J. Fulton, D. Findlay, K.M. Cummings, and A.D. Bryan is to be built no higher than the 1993 flood level. The subject island levee is shown hatched in Figure 9. The small additional hatched island in D.P. Bryan's property is also to be set no higher than the 1993 flood height. The remaining levees and a section of the supply channel in A.D. Bryan's are included in an *hydraulically sensitive area*.

LANDHOLDER/ COMPANY/ PROPERTY NAME	FIG. NO	AREA NO	DETAILS
	9		• Levee on left bank of Coobool Creek in *hydraulically sensitive area*.
	9	A	• Block banks on Gum Creek and Coobool Creek to be lowered to maximum supply level (subject to further environmental assessment).
	9		• Optional 300 metre floodway at Larrys Creek within D. Findlay's property.
Wakool Shire Council	9	A	• Provide additional waterway area at the entrance to Tally's Lake *(Hydraulically sensitive area*). • Lower road crossing over Coobool Creek leading to A. Bryan's, K. Cummings and D. Findlay's properties to low flow level (*Hydraulically sensitive area*).
NSW Public Works and Services	9	A	• Remove abandoned railway line to natural surface over a length of 400 metres adjacent to the Coobool Creek crossing in the area immediately south of the Wetuppa Reserve and situated in J.M. Nixon's property *(Hydraulically sensitive area*).
J.M. Nixon *"Rillwood"* A.N. & J.W.D Fountain *"Errinundra"*	9 9	A	• Levees and irrigation supply channel adjacent to Fountain's Bridge included in an *hydraulically sensitive area*.
Wakool Shire Council	9	A	• Officers Road at Merran Creek - provide 250 metre causeway *(Hydraulically sensitive area).*
B. & G. Basile *"Willakool"*	9	A	• Levee bank in Merran Creek floodway adjacent to R.J. Dunn's property encroaches into the design floodway (*Hydraulically sensitive area*).
	9		• Levees adjacent to G.M. & I.H.

LANDHOLDER/ COMPANY/ PROPERTY NAME	FIG. NO	AREA NO	DETAILS
			Seton-Stewart's and A. & N.M. Pinney's property, downstream of the Waddy Creek and Merran junction, encroach into the design floodway width (350 metres). Levees included in an *hydraulically sensitive area*.
I. Martin *"Mellool"*	9	E	• Levee and channel bank encroach into the design floodway (650 metre width). These works are included in an *hydraulically sensitive area*.
K. Moar	10	E	• Levee and channel banks are included in an *hydraulically sensitive area*. The design floodway is 650 metres wide at the upstream portion of the property and tapers to a width to 500 metres near the Tumbledown Waddy Creek bridge area.
G.M. & I.H. Seton-Stewart; A. & N.M. Pinney *"Merbrae"*	9	E	• Levee on right bank of Merran Creek has been included in an *hydraulically sensitive area*.
G. Foote	13	E	• Levee on left bank of Merran Creek encroaches into the design floodway and has been included in an *hydraulically sensitive area*.
North Star Park Nominees Pty Ltd & Coonwarra Enterprises Pty Ltd	13	E	• Levee and old supply channel at the upstream portion of the property obstruct the design floodway and have been included in an *hydraulically sensitive area*. Workable solution available - see Section 7.2.5 E2.
	13		• Levee adjacent to Coobool Siding included in an *hydraulically sensitive area*.

LANDHOLDER/ COMPANY/ PROPERTY NAME	FIG. NO	AREA NO	DETAILS
G. Moore	13	E	• Channel bank has been included in an *hydraulically sensitive area*. There is a workable solution available - see Section 7.2.5 E2.
T. Vallance *"Studley Park"*	13	E	• Levee bank at northern portion of property (immediately upstream of MR 386 creek crossing) impedes the design flow. It has been included in an *hydraulically sensitive area*. Workable solution available - see Section 7.2.5 E.2.
H. Bourchier "*Moallack"*	13	E	• Levee and channel banks encroach into the design floodway width (500 metres). Included in an *hydraulically sensitive area.*
			• See Section 8.2.6 under "Un-named Wetland 12" and Section 7.2 Sub-Area E2.2 regarding the recommendation of limited height protection in this area.
J.D. & J. Williams	13	E	• Levee and channel banks have been included in an *hydraulically sensitive area*. For the upstream portion of this property, refer to the limited height notes which apply to H. Bourchier's property
H.J. Jager	13	E	• Levee included in an *hydraulically sensitive area.*
D. Nalder *"Glenbar"*	10	B	• Levees obstruct the exit of flows from Cunninyeuk Creek into the Wakool floodplain and have been included in an *hydraulically sensitive area.*
D. Nalder C. & D. Nalder G. Biggs *"Concord"*	10 9 & 10	B A A	• It will be necessary to ensure that the existing levee that protects the subject three properties has a crest height of at least 0.3 metres above the 1993 flood level.
C. & J. Hayes	10	B	• Provide high level flood protection surrounding dwelling.

LANDHOLDER/ COMPANY/ PROPERTY NAME	FIG. NO	AREA NO	DETAILS
	10		• Stock refuge protection area to the north of dwelling as shown in Figure 10.
B. Farrell	10	B	• Provide high level flood protection surrounding dwelling.
	10		• Stock refuge protection area southwest of dwelling.
Coobool Island Pastoral Co.	10	B	• Provide high level flood protection surrounding dwellings adjacent to Coobool Creek.
	10		• Existing supply channel adjacent to "Maronda" may remain.
	10		• Block banks on Coobool Creek to be lowered to maximum supply level (subject to further environmental assessment).
	10		• The levee situated to the north of the "Maronda" homestead to be limited in height to the 1993 flood.
Wakool Shire Council	10	B	• Lower section of Coobool Road on D. Uebergang's property to natural surface (*Hydraulically sensitive area*).
D. Uebergang	10	B	• Provide high level flood protection surrounding dwelling.
A.W., F.R. & D.C. Uebergang	10	B	• Levee banks in area immediately east of "Coobool Island" included in an *hydraulically sensitive area*.
	10		• Levees on the southern bank of Mallan Mallan Creek included in an *hydraulically sensitive area.*
M. Sheldrick *"St. Elmo"*	10	B	• Levees on the left bank of the Wakool Riverjust upstream of Coonamit Bridge have been included in an *hydraulically sensitive area.*
	10	B	• Levee adjacent to Merran Creek encroaches into the design floodway width (500 metres).

LANDHOLDER/ COMPANY/ PROPERTY NAME	FIG. NO	AREA NO	DETAILS
Wakool Shire Council / RTA	10	B	• Provide additional waterway area on road approaches to Coonamit Bridge (*Hydraulically sensitive area*).
N.M. Williams	10 & 11	B & C	• Levee banks on the left bank of the Wakool downstream of Coonamit Bridge extend into the design floodway width (1000 metres). They are included in an *hydraulically sensitive area*.
M. Guy ("Liewah")	10	B	• Provide high level flood protection surrounding dwelling downstream of Coonamit Bridge.
	10 & 11	B & C	• Levee bank and road approach downstream of Coonamit Bridge encroach into the design floodway width (1000 metres) and are included in an *hydraulically sensitive area.*
A.D. & J.W. Pollard *"Erindale"*	11	C	• Northern portion of channel included in an *hydraulically sensitive area*. Workable solution available – see Section 7.2.3 C.3.
J. Tippett *"Mascotte"*	11	C	• Portion of supply channel included in an *hydraulically sensitive area*. Workable solution available - see Section 7.2.3 C.4.
A. Bowring *"Kyalite Pistachios"*	12	D	• Levee banks and a portion of channel bank included in an *hydraulically sensitive area.*
C. Prater	12	D	• Portion of channel bank included in an *hydraulically sensitive area*. Workable solution available - see Section 7.2.4 D.1.
J. Standen *"Tralee"*	12	D	• Northern part of supply channel included in an *hydraulically sensitive area*.
L. Howley "Woodmount"	12	D	• Levee system encroaches into the design floodway and is included in an *hydraulically sensitive area*.

LANDHOLDER/ COMPANY/ PROPERTY NAME	FIG. NO	AREA NO	DETAILS
G. Dalton *"Windomal"*	12	D	• Levee banks included in an *hydraulically sensitive area.*

8. ENVIRONMENTAL ASSESSMENT

The development of agriculture on the lower Edward-Wakool floodplain has had a significant effect on the natural environment. A major part of this effect has been brought about by the widespread construction of levees, channels, storages and roads that act to control flood flows on the floodplain. Flooding is an important natural process that replenishes the floodplain with water and allows large-scale cycling of nutrients and biota. Flooding boosts invertebrate production, promotes interactions between wetland biota, triggers breeding activity in waterbirds and fish, initiates growth and regeneration of River Red Gum and creates extensive areas for aquatic plant colonisation (Lloyd *et al.* 1991). The restriction of flooding has limited habitat opportunities on the floodplain and probably reduced biological productivity. River regulation has also affected the natural environment by altering the flow regime of a number of streams and wetlands on the floodplain for water supply.

While these effects have been significant, the lower Edward-Wakool floodplain retains important ecological values. Large tracts of forested riverine terrain and a significant number of ecologically productive wetlands that support a range of fauna, still occur on the floodplain.

Notwithstanding its ecological value, the lower Edward-Wakool floodplain is important economically, mainly from agriculture, and socially, due to Aboriginal and European settlement. The strategy endeavours to rationalise development on the floodplain so that there is a balance between environmental, economic and social interests.

8.1. Soils and Geomorphology

The Stage IV area lies on the Riverine Plain which consists of a series of gently sloping alluvial fans and the floodplains onto which they merge. The present landform has resulted from a long sequence of sediment deposition, erosion and re-deposition, and mainly controlled by climate, changing sea levels and movements in the earth's crust. The floodplain is dissected by prior streams and ancestral rivers as well as the current creek and river systems (Butler 1973). Wind action has led to the formation of a number of large lakes on the floodplain in the Stage IV area.

Soils on the active part of the floodplain are mainly grey and brown cracking clays over which fine-textured alluvium has been deposited. Red-brown earths have mostly developed on the higher country, no longer subject to deposition. The association between the soils is often complex, forming a mosaic pattern (Dalton 1989).

The lighter textured soils are prone to wind erosion, particularly during dry periods when vegetative cover is sparse. Soil eroded in this way is commonly deposited against barriers such as shrubs and fence lines, leading to the formation of sandy rises.

Johns *et al.* (1984) state that the alluvial cracking clay floodplains are highly productive and resilient rangelands. This is because flooding contributes run-on water, sediment and nutrients, and the soil types spontaneously regain their porosity and structure following a wetting and drying cycle. The blocking of flood flows by levees, therefore, would be expected to have an important effect on the condition of these soils.

The strategy rationalises the existing network of flood control works. Where these works can have a significant effect on the behaviour of floodwaters, the strategy has included them in *hydraulically sensitive areas*. Works in *hydraulically sensitive areas* will be subject to further consultation and analysis. For these works to remain unmodified, further analysis will need to establish that the works will not have a significant hydraulic impact during floods. As well, the works will need to be consistent with the planning principles of Murray REP2. As a result, the strategy is likely to result in significant widening of the existing floodway. An additional area of up to 2000 hectares of the floodplain may be opened up to periodic flooding (a 5 to 10 per cent increase in available floodway area). The ecology of soils within this area would be expected to benefit as a result. The recommended limited height levees will expose a further 2200 hectares to floods larger than the 1993 flood. Inundation of this area would be expected to occur infrequently since the 1993 flood flow has an ARI of about 20 years. Consequently, the benefits of flooding to soils behind the limited height levees would be restricted.

The flow constrictions within the current levee network can generate significantly increased flow velocities during floods. Downstream of these constrictions, this is likely to cause erosion due to scour of the bed or bank. Implementation of the strategy is expected to result in the widening of floodways at current constrictions and the reduction of flood flow velocities. This will minimise this type of erosion.

8.2. Wetlands

8.2.1. General

The lower Edward-Wakool floodplain contains a large number of wetlands of diverse shapes and sizes. For the purposes of this strategy, wetlands are defined as follows:

Wetlands are depressions that are flooded or waterlogged often enough to support aquatic and semi-aquatic plants and animals.

Wetlands include lakes, billabongs, lagoons, swamps, marshes and prior stream channels. Rivers and creeks with predominantly flowing water are functionally interrelated with wetlands but are not considered as wetlands in this strategy. This definition of wetlands is consistent with that described in *Wetland Management Guidelines for Local Councils in the Murray Region (Lugg 1993a).*

Wetlands are of higher ecological value than adjacent drylands because of their higher species diversity and greater productivity. They are intermediate habitats that can support dryland, semi-aquatic and aquatic species as well as accumulating nutrients and retaining moisture for a longer period of time. Wetlands also have an important function in providing flood storage, thereby helping to reduce flood levels and velocities throughout the floodplain.

Wetlands and their associated biota on the Edward-Wakool floodplain have evolved in an environment where water inflows occur over limited periods during floods, normally occurring in winter and spring. Naturally, most wetlands dried out regularly and the biota is adapted to survive this drying period. The drying phase is beneficial to wetlands since it encourages the completion of reproductive cycles, aeration of soils, and promotes breakdown of organic matter and nutrient release. The natural flow regimes of a number of wetlands on the lower Edward-Wakool floodplain have been significantly altered in the course of agricultural development. Some wetlands have been blocked off by levees to provide additional agricultural land while others have been permanently flooded for water storage. The ecological value of these wetlands has been reduced.

The wetlands of the lower Edward-Wakool Rivers were mapped by Pressey (1986) as part of a survey of wetlands on the Murray River floodplain. Pressey identified numerous wetlands (including rivers and creeks) within the Stage IV study area and classified these according to their geomorphologic and hydrologic characteristics. Pressey's mapping, however, was based on aerial photography with limited ground-truthing and consequently, a number of wetlands were overlooked. There were also some discrepancies between mapped and actual wetland boundaries.

The geomorphic types of wetlands (based on Pressey 1986) occurring in the Stage IV area include:

- deflation basins — large wetlands with rounded outlines, typically with a crescent shaped dune (lunette) on the eastern margin. formed by wind deflation of sandy deposits or deflation of clay from exposed lake floors.

- lentic channel forms — oxbow lakes and former channel sections which no longer function as major flow routes.
- depositional basins — broad depressions formed by deposition in old deflation basins.
- scroll swales — curved depressions between the ridges of meander scrolls.
- impounded wetlands — natural wetlands with original outlines expanded due to the raising of water levels by regulating structures.
- floodplain depressions — small, shallow wetlands formed by infilling of a variety of wetland types.
- slackwater areas — small areas of standing water that occur as inlets of the river on the downstream side of meander lobes and which are open to the river channel.

The potential impact of the floodway system on the wetlands is assessed in the following section. As part of this assessment, Pressey's wetland mapping has been adopted and modified based on interpretation of:

- *River Murray Mapping* digital orthophoto imagery and wetland mapping *(Murray-Darling Basin Commission 1993 and 1996)*,
- SPOT satellite imagery and aerial photography of the 1993 flood,
- Ground - truthing.

8.2.2. Areas of Possible Wetland Value

A number of wetlands in the Stage IV area are currently blocked from flooding. Many of these are used directly for agricultural production, including cropping and grazing. Others are surrounded by agricultural land and have been alienated from flooding by flood control works that protect the developed land. The ecological value of the blocked wetlands has been substantially reduced. During the development of the strategy, the return of flooding to these areas was considered. However, where this would result in considerable economic or social impact to landholders, the wetlands were not included in the design floodway.

Notwithstanding this, the continued blockage of the wetlands is contrary to specific planning principles of Murray REP2. These relate to the

maintenance or restoration of wetlands, the benefits to riverine ecosystems of periodic flooding and the avoidance of adverse effects on the quality of terrestrial and aquatic habitats. Furthermore, the blockage of flood flows is inconsistent with the goal of the *NSW Wetlands Management Policy* that is the ecologically sustainable use, management and conservation of wetlands in NSW for the benefit of present and future generations.

In order to address these issues, the strategy has included the blocked wetlands in special *areas of possible wetland value* and has set up a process for the further environmental assessment of these areas.

Areas of possible wetland value are areas of formerly functional wetlands that have been blocked from flooding because of agricultural or transport development, and are situated outside the design floodway. The ecological value of these areas has been reduced but options for their future rehabilitation may be possible.

The ecological value of these areas throughout the floodplain is variable. Additionally, the potential for returning flood flows to these areas will vary according to social and economic factors, including flood risk impacts. Where rehabilitation potential is high, the return of flooding would be expected to realise a number of important environmental benefits. These would include increased biological productivity, enhanced habitat for native fish and waterbirds, improved health and regeneration of riverine tree species, and flushing of surface salts. DLWC has specific responsibilities, under *Part 8 of the Water Act*, to assess works blocking flows to *areas of possible wetland value*. DLWC is required to carry out an environmental assessment under *Part 5 of the EPA Act* for existing works constructed before the gazettal of Murray REP2 (1994).

Within this legal framework, the strategy outlines a process for further environmental assessment which will be based on the individual merits of each *area of possible wetland value* and will stress a co-operative approach in exploring possible options for returning flood flows to these areas. This process is set out below.

8.2.3. Further Environmental Assessment of Areas of Possible Wetland Value

Flood control works that block flows to *areas of possible wetland value* include privately owned works that are licenseable under *Part 8 of the Water Act* and government works, such as roads, that are not licenseable under the Act. While some of the existing privately owned flood control works are currently licensed, the vast majority are not.

When assessing licence applications or renewals for existing flood control works affecting *areas of possible wetland value*, DLWC will consider the

environmental impacts in line with the requirements of *Part 5 of the EPA Act*. This assessment will be done in the following way:

- ***For licence renewals***, the environmental assessment will be broad in nature. DLWC will consult with the landholder to explore any practical options for restoring a flooding regime to the area of possible wetland value. Workable outcomes would be attached as a condition of the renewed licence. Licence renewals are required at five yearly intervals.
- ***For licence applications***, DLWC will initially evaluate the environmental significance of the *area of possible wetland value*. The level of detail required in the environmental assessment would then be based on the significance of the area. If an area has low potential environmental value, the required assessment would not be detailed. Conversely, if an area has high potential environmental value, a more detailed assessment would be required. If the area is environmentally significant an EIS would be required.

DLWC will apply a set of criteria in determining the environmental significance of an *area of possible wetland value*. These criteria, which will be developed in consultation with the Murray Wetlands Working Group, would be based on measures of:

- size
- ecological condition
- representativeness of the wetland type
- habitat value
- cultural or historical significance

Within the context of legal requirements, DLWC will take a co-operative and pragmatic approach in exploring potential options to return seasonal flooding to areas of *possible wetland value*. As well as an analysis of ecological impacts, the environmental assessment would include an analysis of flood risk, and considerations of social and economic factors. Potential options to enhance ecological condition may involve partial flooding or regulated inflows to these areas. Some hydraulic analysis may be required to design flow control structures into these areas. The Murray Wetlands Working Group will take an advisory role in assessing rehabilitation options.

Existing government flood control works are outside the scope of the *Water Act* and therefore do not trigger an environmental assessment as part of a licensing requirement. Where these works affect *areas of possible wetland value*, the strategy recommends that the local council or other agency responsible for the work considers them when planning any modifications to the works. The agencies would consult with DLWC and affected

landholders regarding any workable options for returning a flooding regime to these areas.

8.2.4. Wetland Maps

Wetlands and *areas of possible wetland value* in the Stage IV area are shown relative to the floodway limits in Figures 14 to 18. An index plan of the wetland maps is shown in Figure 8. Further to Pressey's survey, 72 wetlands (70 numbered as un-named wetlands, and two wetlands with geographic names) were included in the mapping. Government flood control works affecting flows to *areas of possible wetland value* are highlighted on the maps for the attention of the agencies responsible for them.

The following assessment is structured so that wetlands and *areas of possible wetland value* associated with each major anabranch are analysed separately. For the purposes of this report, wetlands larger than 50 hectares are assessed as discrete units, whereas small wetlands are assessed within larger complexes.

8.2.5. Waddy Creek

There are three wetlands and an *area of possible wetland value* associated with Waddy Creek (Figure 14). These comprise a lentic channel form and three depositional basins. The total wetland area is about 40 hectares. The the downstream reach of Old Waddy Creek is a lentic channel form that has been blocked at the Murray River to prevent inundation of agricultural land. The creek is also blocked at its downstream end to prevent Waddy Creek flows from backing up the channel. The removal of this block bank would lead to substantial flooding of agricultural land and access roads, causing considerable disruption and economic disadvantage. For these reasons, this former wetland has been excluded from the floodway and included in an *area of possible wetland value*. As such, the area will undergo further environmental assessment as outlined in Section 8.2.3.

The remaining wetlands along Waddy Creek lie within the floodway limits and will, therefore, continue to be exposed to periodic flooding. This will enable the ecological productivity of these wetlands to be maintained.

8.2.6. Merran Creek

There are seven large wetlands (deflation basins) and 55 small wetlands including lentic channel forms, depositional basins and floodplain depressions scattered along Merran Creek and its associated effluent streams in the study area - St Helena, Mulligans, Larrys and Coobool Creeks.

Wetlands Complex

The 55 small wetlands associated with Merran Creek have a total area of about 250 hectares. According to Pressey, nearly all of these wetlands are filled above maximum regulated flow level. One wetland (Pressey Number1268), a billabong connected to Merran Creek, is blocked to store surplus flows for water supply. A block bank on an anabranch of Coobool Creek diverts water into the Tallys Lake offtake for water storage and creates a backwater effect which artificially inundates wetland No 1350.

Forty-eight of the small wetlands lie within the floodway limits. Eight wetlands, currently blocked from flooding, have been excluded from the floodway. This is because the economic disbenefits associated with restoring a flood regime to these former wetlands were considered to be substantial. These former wetlands are mapped as *areas of possible wetland value* so that options for enhancing ecological condition can be explored as part of future environmental assessment. These areas are as follows:

- Five former wetlands adjacent to Mulligans Creek (Nos 1410, 1408, 1409, 1411 and Un-named Wetland 2). These are lentic channel forms with a combined area of 18 hectares and are shown on Figure 14. Except for No 1414, the former wetlands are located on Mulligans Plain where a limited height levee is recommended in the floodway. They will be exposed to floods larger than the 1993 flood, which has an ARI of about 20 years. Consequently, they will receive restricted ecological benefits.

- A small section (0.5 hectares) of Wetland 1407, a lentic channel form at the northern end of Mulligan's Plain (Figure 14). This area would be exposed to floods larger than the 1993 flood and receive restricted ecological benefits.

- Wetland No 1422 (two hectares), a lentic channel form adjacent to Larrys Creek (Figure 14). The strategy recommends that levees currently protecting agricultural land on which this wetland is located are limited in height to the level of the 1993 flood. This wetland will receive restricted ecological benefits since it will be inundated only during floods larger than the 20 year ARI flood.

- Wetland No 1264, a lentic channel form of 25 hectares, lies within a large deflation basin (Un-named Wetland 12) which is outside the design floodway. This wetland is discussed within this context below.

Alienation or restriction of wetlands from flooding is not consistent with the planning principles of Murray REP2. Further environmental assessment of these *areas of possible wetland value* will be carried out when licences for works affecting them are assessed or reviewed (Section 8.2.3).

The strategy has identified a number of *hydraulically sensitive areas* along the Merran Creek system. Flood control works in these areas can impede

flood flows and will be the subject of further consultation and analysis. Preferred options from this analysis will need to be consistent with the planning principles of Murray REP2. Specifically, where the works affect a wetland, the land use decision should provide for a hydrologic regime appropriate for the maintenance or restoration of the productive capacity of the wetland. Accordingly, the strategy is expected to restore flooding to eight wetlands (combined area 33 hectares) that are currently situated in the design floodway but blocked off from floodwaters. These wetlands include the following:

- Wetland No 1407 (six hectares) which links Mulligans Creek to St Helena Creek on "Burnside" (Ady, S.) (Figure 14). Two levees and a block bank currently block flood flows to the main channel of this wetland and affect its productive capacity. A small section of this wetland, currently blocked off by a separate levee, has been excluded from the floodway so that agricultural land on Mulligans Plain is protected. This section is included in an *area of possible wetland value*.

- Wetland No 1412 (two hectares) which is a lentic channel form on the left bank of Mulligans Creek upstream of Fishers Lane (Figure 14).

- Wetland No 1438 (eight hectares) which is a depositional basin on the left bank of Merran Creek near the Waddy Creek confluence (Figure 14).

- Wetland No 1263 (three hectares), a lentic channel form on the right bank of Merran Creek near the MR 386 crossing (Figure 15).

- Wetlands Nos 1329, 1330, 1331, 1332 which are lentic channel forms (combined area 14 hectares) on the right bank of Coobool Creek downstream of the offtake to Tallys Lake (Figure 15).

Wilsons Lake (No 1433)

Wilsons Lake is a large deflation basin with an area of 105 hectares (Figure 14). The outflow channel from the lake has also been identified as a wetland by Pressey (1986). Under natural conditions, the lake filled during floods from Murray River and Bullockhide Creek flows. Following blockage of these inflows, however, the lake has filled infrequently. During the 1956 flood, high ground between the Bullockhide Creek anabranch and the lake was breached and the lake was filled. Subsequently, Wakool Shire Council constructed a levee in this area to prevent water from the lake flooding Noorong Road to the south. Since this time, the lake has been isolated from floodwaters. During the 1993 flood event, the lake filled from rainfall. Wilsons Lake has been cleared of native vegetation and is currently under cultivation.

Wilsons Lake is economically significant to the landholder and its opening up to flooding would reduce this value. Outflows from the lake via wetland Number 1434 would also inundate a substantial portion of the adjoining property to the north. Extra cost would be incurred in providing earthworks along the southern edge of the lake to prevent flooding of Noorong Road. For these reasons, Wilsons Lake and its outflow channel were not included within the floodway limits. The continued alienation of the lake, however, is not in line with the planning principles of Murray REP2. The lake and the associated Wetland 1434 have therefore been mapped as *areas of potential wetland value* and need to be considered by Wakool Shire Council when planning any modifications to the associated flood control works (Section 8.2.3).

Un-named Wetland 4 ("Merranleigh")

This wetland is a deflation basin of about 330 hectares in area (Figure 14). It was not identified in the Pressey survey. Inflows to this wetland have been blocked by a levee on the bank of Merran Creek and a block bank across the connecting channel. The wetland has been developed with an irrigation layout and is used for cropping and grazing. The wetland has not been flooded since 1960.

The strategy has included flood control works affecting this wetland in an *hydraulically sensitive area*. Any further analysis of these works will need to produce an outcome consistent with the planning principles of Murray REP2. Accordingly, the strategy is likely to return a flooding regime to the 50 hectare portion of this wetland which is located in the design floodway. Given the existing use of the remainder of the wetland and the extent of development within it, however, the remaining part of the wetland was not included within the floodway limits. This section of the wetland occupies about 50 per cent of the area of the "Merranleigh" property (Bryan, R. J & James - Bryan, J.) and restoration of a flooding regime to this area is likely to cause economic disadvantage. The continued alienation of this former wetland however contravenes the planning principles of Murray REP2 and it has been included in *an area of possible wetland value*. The area will undergo further environmental analysis so that options for enhancing its ecological condition can be explored when the works affecting it are assessed for licensing purposes (Section 8.2.3).

Tallys Lake (No 1351)

Tallys Lake is a deflation basin with an area of 110 hectares (Figure 14). The wetland is used to store surplus flows for irrigation and stock and domestic usage. Storage is controlled by a flow regulator in the lake's outflow channel. The lake is shallow (1.5 metres) and under natural conditions would have dried out regularly. Excessive inundation has caused a number of tree deaths in the fringing vegetation of the lake. Current management

allows for the lake to dry out only during drought periods. This limited drying phase is likely to have reduced the productive capacity of the lake. Nevertheless, the lake sustains significant ecological productivity following its infrequent drying periods and is an important drought refuge for waterbirds.

The floodplain management strategy will enable the existing ecological values of Tallys Lake to be maintained since the lake is wholly within the floodway limits.

Lake Tooim (No 1361)

Lake Tooim is a large deflation basin with an area of 355 hectares (Figure 18). This wetland is used for water supply and is filled from surplus flows. A block bank in the channel connecting the lake to Merran Creek is removed and re-installed to control surplus inflows. The lake has not dried out since the 1960s. The wetland is deep (about five metres) and under natural conditions, would have probably dried out infrequently. Current management keeps the water at an artificially high level. There is some evidence of waterlogging in River Red Gums at the water's edge.

The lake retains important ecological values. Lake Tooim holds relatively large volumes of water for long periods of time and is likely to be a significant drought refuge for waterbirds. Large numbers of ducks have been observed on the lake in recent years.

The floodway limits in the strategy will not affect the delivery of floodwaters to the lake and will not impact on the existing ecological or economic values of the lake.

Un-named Wetland 10 ("Coobool" and "Merbrae")

This wetland, known locally as "Coobool Swamp", was not included in the Pressey survey. The wetland is a deflation basin with an area of about 980 hectares (Figure 18). It supports an extensive woodland dominated by Black Box (*E. largiflorens*). This wetland formation is unusual in the region (NPWS 1982), mainly because most of the other large deflation basin wetlands in the area have an open water habitat. The wetland has significant conservation value. During the 1993 flood, it supported significant communities of aquatic vegetation. Because of its size, it is also important in terms of providing en-route storage for flood mitigation.

Ninety per cent (approximately) of the wetland is included within the floodway limits. The remaining 10 per cent has been developed for rice cultivation and is currently protected by a levee system. Because of the intensity of development, this part of the wetland has been excluded from the floodway. The blocking of this part of the wetland, however, is not in

keeping with the principles of Murray REP2. Consequently, this part of the wetland has been included in *an area of possible wetland value* and will undergo further environmental assessment when the works affecting it are assessed for licensing (Section 8.2.3).

The remainder of the wetland is located within the floodway limits and will continue to be exposed to the flooding regime. Its important ecological and floodplain storage values will be maintained.

Un-named Wetland 11 ("Studley Park" and"Moallack")

This wetland is a floodplain depression covering an area of about 150 hectares (Figure 18). Native vegetation has been cleared from the wetland and it is currently under cultivation. Earthworks on Merran Creek at the upstream and downstream ends of the depression have isolated the wetland from flooding. The downstream levee, however, was breached during the 1993 flood and the wetland was inundated. A series of pipes passes water under the Swan Hill-Moulamein Road which traverses the depression.

Current land use in this wetland is important economically to the landholders, who wish to retain flood protection. The landholder on "Moallack", however, is willing to allow floods with an average return period of five years or more to inundate the section of the depression downstream of the Swan Hill-Moulamein Road (about 100 hectares). This will provide additional floodplain storage and be beneficial to soils in the depression. Floodwaters would enter from the downstream end of the depression and would be contained on "Moallack" (Bourchier, H.) by using flap gates on the pipes under the Swan Hill-Moulamein Road. This section of the depression is included within the floodway.

Existing cultivation practices will be continued and this may limit the value of the depression as a wetland ecosystem. Briggs (1994), in a study of lakebed cropping in north western NSW, found that fewer aquatic invertebrates emerged from cropped soils than from unfarmed lakebeds although the overall differences were not significant. Repeated cultivation altered the structure and composition of soils, prevented cracks from forming and prevented the establishment of native vegetation.

The partial flooding of part of this wetland is likely to generate some ecological benefits and improve floodplain storage. The partial hydrological regime, however, may not be appropriate for the restoration of the productive capacity of this wetland. For this reason, it may not be in keeping with Murray REP2 planning principles and has been included in an *area of possible wetland value*. The area will undergo further environmental assessment as outlined in Section 8.2.3 when the works affecting it are assessed for licensing.

Un-named Wetland 12 ("Moallack", "St Elmo" and "Redbank")

Merran Creek passes through the centre of this large deflation basin that has an area of about 1100 hectares (Figure 15). Pressey (1986) identified four lentic channel forms here (Nos 1263, 1264, 1265 and 1268), but did not include the large basin in his survey.

The basin has been largely cleared of native vegetation and is used for cropping and some grazing. Agricultural development has been more intensive on the eastern side of the basin (on "St Elmo" and "Red Bank") where there is an extensive irrigation layout. Levee banks on Merran Creek isolate the basin from flooding, however, earthworks on the western side were breached during the 1993 flood and this side of the basin filled. The landholders within the basin wish to retain flood protection since current agricultural development is economically significant. The landholder at "Moallack" is willing to allow floods with an average return period of five years or more to inundate the western side of the basin to improve soil condition. This will increase flood storage and will enhance the value of the basin as a wetland. This value will be limited since existing cultivation practices will be continued.

The strategy has included about 80 per cent of the western side of the basin within the floodway. The proviso is that, by retaining limited height levees, there will be flood protection from minor and moderate floods. The remaining 20 per cent of the basin, which contains a supply channel, and the intensively developed eastern side of the basin, have been excluded from the floodway.

Although the partial flooding of the western part of this wetland is likely to generate some ecological benefits and improve floodplain storage, this hydrological regime may not be appropriate for the restoration of the productive capacity of this wetland. For this reason, it may not be in keeping with Murray REP2 planning principles. This section and the remainder of Un-named Wetland 12 have been included in an *area of possible wetland value*. Further environmental assessment will be carried out when the flood control works affecting it are assessed for licensing, as outlined in Section 8.2.3.

Amendments to the Draft Wetland Maps

Wetlands outside the design floodway were ground truthed following the release of the draft strategy. Following this, three wetlands previously mapped in the Merran Creek system (Un-named Wetland 5, Wetland Nos 1414 and 1349) were removed from the maps:

- Un-named Wetland 5 is a deflation basin of 75 hectares in area. The basin filled in the 1956 flood, however the passage of floodwaters to it

has been permanently altered by the effect of natural chokes caused by wind drift.

- Wetland No 1414 is a drainage ditch which was incorrectly mapped from aerial imagery.

- Wetland No 1349 has no geomorphic boundaries and supports native tree species which are not flood dependent.

8.2.7. Wakool River

The Wakool River has extensive floodplain wetlands along its course throughout the Stage IV area. These wetlands extend for a width of up to five kilometres across the floodplain and during floods are filled from the river or from its Wyam Creek anabranch. This complex of wetlands comprises numerous small wetlands. There are three larger wetlands. These include Wee Wee Creek and two un-named deflation basins.

Wetland Complex

There are 359 small wetlands associated with the Wakool River in the Stage IV area. These wetlands cover a total area of about 1800 hectares and consist predominantly of lentic channel forms (such as billabongs, oxbow lakes and prior stream channels). Floodplain depressions and depositional basins are also common along the reach. Pressey (1986) identified 12 scroll swale wetlands, most of which are located near Wee Wee Creek. Two wetlands (Nos 157 and 178) were classified as slackwater areas. Nine wetlands adjacent to the Murray River just upstream of Wakool Junction have been included in this complex. Because of hydrological connections, two large wetlands (Un-named Wetlands 40 and 43), each of 75 hectares in area, are assessed below as part the complex of wetlands beyond the left bank of the Wakool downstream of Kyalite.

A number of the wetlands are used for water storage. A regulator on Coobool Creek and a system of block banks are used to store regulated flows in a complex of wetlands adjacent to Gum Creek and the Wakool River (Nos 1326, 1323 and 1213). As well, a block bank is used to store water in Wetland No 1110 just upstream of the Merran Creek confluence. These wetlands are generally permanently inundated and only dry out during periods of drought. The wetlands have reduced ecological productivity due to their lack of a drying phase.

Except for 16 wetlands, the complex of small wetlands associated with the Wakool River lies within the floodway limits and will be exposed to periodic flooding. This will enable the ecological productivity of these wetlands to be maintained.

The 16 wetlands outside the floodway limits lie on developed land that is currently alienated from floodwaters. These former wetlands were excluded from the floodway and have been mapped as areas of *possible wetland value*. It was considered that opening them up to flooding would cause considerable disruption and economic disadvantage. The *areas of possible wetland value* include the following:

- Part of Wetland No 1390, a lentic channel form connecting Wyam Creek to the Wakool River (Figure 14). The affected section of the wetland is blocked by a supply channel and a levee. This section of the wetland filled during 1993 from floodwaters that backed up from Wyam Creek. It receives some ecological benefits during large floods under the present system of flood control works.

- Part of Wetland No 1339, a lentic channel form adjoining Larrys Creek and the Wakool River (Figure 14). The affected part of the wetland is blocked by a block bank.

- Two lentic channel forms on Coobool Island (Nos 1221 and 1222). These have a combined area of eight hectares (Figure 15).

- Wetland No 1421 (five hectares), a billabong adjacent to the Wakool River and Larrys Creek (Figure 14). A block bank prevents Wakool flows from filling this wetland.

- A group of eleven wetlands beyond the left bank of the Wakool River downstream of Kyalite. These wetlands have been blocked from flooding by the Tooleybuc - Kyalite Road and by a system of levees and channel banks adjacent to the Wakool River. Two of the wetlands (Un-named Wetlands 40 and 43) are large deflation basins but have been assessed along with the small wetlands because of hydrological connections. The small wetlands in this complex include Nos 180, 182, 179, 192, 193, 194, 195 and Un-named Wetlands 39, and 80. The wetlands (Figure 17) have a combined area of about 210 hectares. Under natural conditions, these wetlands were interlinked by a system of channels. The southern part of the system drained to Bingera Creek and thence, the Murray River, while the northern part drained to the Wakool. The drainage network has been altered to provide water storage in some of the wetlands and to prevent outflows to Bingera Creek. The land surrounding the wetlands has been developed for agriculture, in particular, irrigated cultivation. Un-named Wetlands 40, 43 and 80 are cropped and contain intensive irrigation layouts.

These areas will undergo further environmental assessment so that options for enhancing their environmental condition can be explored in line with the planning principles of Murray REP2. Section 8.2.3 outlines this process. The nature of this assessment will be guided by the licensing status of works affecting them. Where government roads block flows to the areas, the

strategy maps highlight these works so that the government agencies responsible consider the areas when planning any modifications to the roads.

The floodplain management strategy has identified a number of *hydraulically sensitive areas* along the Wakool River. Flood control works in these areas can significantly affect the distribution of flood flows and will be the subject of further consultation and analysis. Preferred options from this analysis will need to be consistent with the planning principles of Murray REP2. Specifically, where the works affect a wetland, the land use decision should provide for a hydrologic regime appropriate for the maintenance or restoration of the productive capacity of the wetland. Accordingly, the strategy is expected to restore a flooding regime to three wetlands with a combined area of 18 hectares that are situated in the design floodway but are presently isolated from flooding. The strategy will in this way act to restore the productive capacity of these wetlands. The wetlands include the following:

- Wetland No 1213, a lentic channel form near the left bank of the Wakool River near the confluence of Gum Creek (Figure 15).

- Wetlands Nos 1059 and 1069, lentic channel forms near Coonamit Bridge (Figure 15).

Wee Wee Creek (No 81)

Wee Wee Creek is a large billabong chain (240 hectares) near the junction of the Murray and Wakool Rivers (Figure 17). The wetland is a lentic channel form that, during floods, receives flows initially from the Murray River at its downstream end and then from the Wakool River at its upstream end. Following floods, the creek dries and becomes a chain of long isolated pools.

Except for a low-level bank near the "Woodmount" (Howley, L.) homestead, flows along the watercourse are unrestricted. This bank blocks part of the watercourse to conserve stock and domestic supplies. The bank is drowned out during floods and does not restrict high flows.

Wee Wee Creek is an ecologically productive wetland that is largely unmodified by flow control structures. It is lined by extensive areas of riverine woodland. Gerhke and McLean (1988) identified the wetland as an important fish habitat. Pools along the creek function as refuge areas for fish populations that colonise dry tributary sections when the creek is flowing again. Brady *et al.* (1991) noted the wetland as a valuable waterfowl breeding site.

The floodplain management strategy will enable the ecological values of Wee Wee Creek to be maintained since the wetland is contained wholly within the floodway limits.

Bingera Creek

This former effluent creek which carried flood flows from the Wakool River to the Murray River has been blocked for many years (prior to 1956) to protect development along its course. The effluent is blocked at the Stoney Crossing Road, at the Tooleybuc - Kyalite Road, and further downstream where it is used to hold water extracted from the Murray. Although the creek is well defined along its middle and lower reaches, there is little evidence of a channel system at its upstream end. As outlined in Section 7.2.3 C4, it is probable that flows breaking out of the Wakool initially passed overland as sheet flow. Agricultural development at the upstream end of the creek is likely to have altered some of the natural flow paths. The creek line becomes well defined at a distance of about five kilometres from its former source and remains well defined for a further 10 kilometres until it reaches the Murray.

Although the existing watercourse is bordered by vegetation and retains some ecological value, the lack of an inflow channel for a distance of five kilometres presents a considerable practical difficulty in enhancing this value. For this reason, the creek has not been mapped as an *area of possible wetland value* for the purposes of this strategy.

Lanker, Noorong and Armstrong Creeks

This system of effluent creeks that flowed from the Wakool River upstream of the Stage IV area into Wyam Creek was blocked following the 1956 flood to protect developed land along its course. The levees blocking flows to this system are in the Stage II area and have not been assessed in the present study. It is important to note, however, that these banks are not consistent with the planning principles of Murray REP2. A review of the Stage II guidelines is planned in the near future. At that stage, the banks will be re-assessed.

Amendments to the Draft Wetland Maps

Five wetlands previously mapped in the draft strategy have been removed from the maps following ground truthing:

- Un-named Wetlands 41and 42 are sandhills that were incorrectly mapped from aerial imagery.
- Un-named Wetland 44 is a depression that fills from local runoff and not from river flows.

- Un-named Wetlands 71 and 72 have no discrete geomorphic boundaries and are part of a general floodplain area.

8.2.8. Cunninyeuk Creek / Niemur River

There are 17 small wetlands with a total area of 55 hectares that are filled mainly from flows in the Cunninyeuk Creek and Niemur River. These include wetlands along Mallan Mallan Creek (Figure 15). Wakool River flood flows also contribute to these wetlands. The wetlands consist of lentic channel forms, depositional basins and a floodplain depression.

Pressey (1986) has identified an anabranch of Mallan Creek that joined the Wakool River downstream of Coonamit Bridge as a lentic channel form (No 1052). This anabranch has been blocked at Mallan Creek and on MR 386.The blockage also prevents flooding of Un-named Wetland 56, a lentic channel form of about two hectares in area. The floodplain management strategy has excluded the anabranch and its associated wetland from the floodway. This is because opening up these systems would potentially cause considerable damage and disruption by flooding developed land along their course. Similarly, a small former wetland (No 1151) adjacent to Cunninyeuk Creek is outside the floodway.

These former wetlands have been mapped in the strategy as *areas of possible wetland value* so that options for enhancing their ecological condition can be explored in a future environmental assessment. The procedures for this assessment are outlined in Section 8.2.3. The government road affecting No 1052 is highlighted on the strategy maps so that the agency responsible can consider this *area of possible wetland value* when planning any modifications to the road.

The remaining wetlands within the Cunninyeuk Creek / Niemur River complex lie within the floodway limits and will be exposed to periodic flooding.

8.2.9. Edward River / Yarrein Creek Wetlands

Surplus flows in the Edward River and Yarrein Creek fill a complex of 66 small wetlands in the Stage IV area. Many of these wetlands can also be inundated by backwater flows from the Wakool River. There are also two large wetlands - Lake Talbetts and Un-named Wetland 79 that are both blocked from flooding.

Wetland Complex

The wetlands within this complex comprise mainly lentic channel forms with a small number of floodplain depressions and depositional basins. The

total area of the wetlands is about 300 hectares. The floodplain management strategy includes all of the wetlands within the floodway limits.

Lake Talbetts

Lake Talbetts is a deflation basin of 170 hectares that in the past filled from high Edward River flows via Forest Creek (Figure 17). The creek has been blocked by the Kyalite - Moulamein road (which has a small capacity pipe system beneath it), a supply channel and by Arundel Road at several crossings. The lake has been isolated from floodwaters since the 1956 flood when it held over 2 metres of water. Some cropping has been undertaken in the lakebed, but this has been recently scaled down because of increasing salinity problems.

The opening up of Forest Creek to flooding could potentially damage areas of irrigated cropland along its course and inundate access roads leading to several properties. For these reasons, Lake Talbetts and Forest Creek have been excluded from the floodway. However, since this hydrological regime is not consistent with the principles of Murray REP2, Lake Talbetts and Forest Creek have been included in an *area of possible wetland value* so that options for returning flood flows to the system can be explored in a future environmental assessment. The process for this assessment is outlined in Section 8.2.3.

Un-named Wetland 79

This deflation basin has an area of about 65 hectares and has been substantially modified for irrigated cropping (Figure 16). The inflow channel connecting the wetland to the Edward River has been blocked by a supply channel and the Kyalite - Moulamein Road. The bed of the wetland has an irrigation layout and is currently under cultivation.

Due to intensive development affecting the former wetland and its inflow channel, it has been excluded from the floodway. The system has been included in an *area of possible wetland value* (Figure 16) so that options for enhancing its ecological value may be explored as part of any future environmental assessment. Section 8.2.3 sets out this process.

8.2.10.Murray River downstream of Wee Wee Creek

There are 14 small wetlands adjacent to the reach of the Murray River downstream of the Wee Wee Creek junction in the Stage IV area (Figure 17). These wetlands consist mainly of lentic channel forms and have a total area of about 80 hectares. The wetlands within this reach are contained within the limits of the design floodway. Seven of the wetlands however, are affected by levee systems on the right bank of the Murray River near the

Wee Wee Creek confluence. These levee systems have been included in *hydraulically sensitive areas*.

The levee on "Woodmount", which was constructed following the 1993 flood, blocks flood flows to Wetland Nos 87, 92 and Un-named Wetland 51. Part of the levee system on "Windomal"is currently used to capture flood flows for water supply and contains two wetlands, an oxbow lake (No 69) of 21 hectares in area, and a small floodplain depression (No 93). The levee to the north of this storage area currently isolates Wetland Nos 70 and 71 from flood flows.

Outcomes from further analysis of the *hydraulically sensitive area* will need to be consistent with the planning principles of Murray REP2. In particular, the outcomes will need to provide a hydrologic regime appropriate for maintaining or restoring the productive capacity of the wetlands. Accordingly, the strategy is expected to restore a more natural hydrologic regime to the wetlands currently affected by these levee systems.

8.2.11.General Impacts on Wetlands

A total of 515 small wetlands and 12 large wetlands (greater than 50 hectares) occur in the Stage IV area. A number of these wetlands have been blocked from flooding. These include wetlands that are used directly for agricultural production and those that are surrounded by developed land. This land use is important economically to landholders, but substantially reduces the ecological value of the wetlands. Where the return of flooding to these wetlands was considered to have potentially high social or economic impacts, the wetlands were not included in the floodway. Seven of the large wetlands and 26 of the small wetlands in the Stage IV area are not in the floodway. Notwithstanding this, the strategy recognises that options for the rehabilitation of these areas may be possible but need to be explored on an individual basis. Accordingly, the former wetlands have been mapped as areas of *possible wetland value*. This means that when works affecting these areas are assessed for licensing purposes, or when government agencies plan modifications to these works, options for the return of flooding will be considered. The ecological value of the *areas of possible wetland value* varies throughout the floodplain and as a result, the potential for rehabilitation is also variable.

As with the Wakool Irrigation District to the north, the Stage IV area is underlain by extensive shallow watertables which are generally highly saline. Wetlands are the lowest points of the landscape and are susceptible to groundwater encroachment. If blocked, they will not be flushed during floods. This is likely to lead to a build up of saline sediments and the gradual salinisation of the blocked wetlands. There is some evidence of this process occurring at Lake Talbetts in the Stage IV area.

Ninety-five per cent of small wetlands and 42 per cent of large wetlands in the Stage IV area are included within the floodway. Flood control works affecting wetlands in the design floodway have been included in *hydraulically sensitive areas*. Consultation with landholders and further analysis will be carried out to determine outcomes for these works. Any outcomes will need to be consistent with the planning principles of Murray REP2 regarding the maintenance or restoration of wetlands. Accordingly, the strategy is expected to return a more natural flooding regime to 18 small wetlands (total area 80 hectares) currently situated in the design floodway and affected by flood control works. The ecological value of these wetlands should be enhanced as a result. Further, the partial floodway at two large wetlands on Merran Creek will improve the flooding regime and hence the productive capacity of these wetlands.

The inclusion of wetlands within the floodway will ensure that these wetlands receive periodic flooding. It is important to note, however, that this flooding regime will vary from the natural regime. Although the floodway has been hydraulically designed to provide adequate capacity, the concentration of floodwaters between any banks that may be located at the floodway limits will act to increase flood magnitude and duration within the floodway. The floodway design, therefore, has the potential to adversely affect wetlands by altering their natural wetting and drying cycle. Generally, this impact is not expected to be significant however, since it would be largely offset by the effects of river regulation on the Murray River and its tributaries. This has the effect of reducing flood frequency, magnitude and duration, most notably on small to medium-sized floods.

8.3. Floodplain Vegetation

8.3.1. Description

Native vegetation on the lower Edward-Wakool floodplain broadly consists of communities dominated by Black Box (*E. largiflorens*) and River Red Gum (*E. camaldulensis*). The pattern of vegetation is based on the frequency of flooding. Black Box communities occur in less frequently flooded areas than River Red Gum. Typically, River Red Gum occurs on the inner areas of the floodplain adjacent to the watercourses while the outer more elevated floodplain supports Black Box communities. Stands of Black Box take on a woodland structure with individual trees reaching a height of 10 to 14 metres. River Red Gum is the tallest tree species in the area and occurs as open riverine forest on some reaches of the Edward and Wakool Rivers, and in woodlands associated with Black Box. River Red Gum also occurs in stands, one or two trees wide, along the banks of the smaller watercourses such as Merran, Mulligans and Larrys Creeks. Along the Wakool River and its anabranches, there is a continuous tract of riverine forest/woodland through the Stage IV area. This is in contrast to the remainder of the area, which is mainly agricultural grassland or cropland. Isolated stands of mallee

(E. dumosa and E. socialis) occur on higher ground near the downstream reaches of Merran Creek.

The understorey of River Red Gum woodlands in the area is generally devoid of shrubs. It is dominated by plants that tolerate inundation, particularly grasses, sedges and rushes. Black box communities have a shrubbier understorey. The main shrub species observed on the floodplain are lignum *(Muehlenbeckia cunninghamiana)* and Dillon Bush *(Nitraria billardierei)*. Lignum occurs in isolated thickets and does not form extensive swamps on the floodplain.

Most of the large deflation basin wetlands in the Stage IV area are predominantly open water habitats with little dense or tall vegetation. Wetlands in the study area that are subject to cyclic flooding and drying generally support wetland vegetation during flooding. Stands of Common Reed and Giant Rush have developed along reaches of Coobool Creek where water is ponded by block banks.

The Atlas of NSW Wildlife (NPWS 1996) shows that there are three threatened plant species, as listed on the Schedules of the *Threatened Species Conservation Act (1995),* that have been recorded in the Stage IV area:

- *Callitriche cyclocarpa*
- *Stipa metatoris*
- *Stipa wakoolica*

Based on information in the DLWC Threatened Plants Database (1996), a further three threatened plant species may occur in the lower Edward-Wakool area:

- *Lepidium monoplocoides*
- *Maireana cheelii*
- *Solanum karsense*

8.3.2. Condition

Human occupation has had a significant impact on the vegetation of the floodplain. Aboriginal burning practices for food - gathering and hunting would have influenced the vegetation over a long period of time (Scott 1992). Since European settlement, clearing for agriculture, grazing, fire, feral animals, salinisation, flow regulation and flood control have been significant impacts. Scott (1992) states that clearing in the Swan Hill area has been widespread and that Black Box would have covered much of the floodplain. Margules *et al.* (1990) observed that vegetation in the complex network of anabranches between the Murray and Edward Rivers has undergone extensive clearing. This clearing has mainly affected Black Box

woodlands. River Red Gum forests in the area have been largely retained as a timber resource (Margules *et al.* 1990). Existing River Red Gum forests are largely contained within three State Forests - Wetuppa, Liewa and Kyalite. These forests have a combined area of 2050 hectares.

Like River Red Gum, natural regeneration of Black Box is largely dependent on flooding (Margules *et al.* 1990). Clearly, Black Box communities isolated from floodwaters by levees will be significantly affected in the long-term.

Grazing also affects eucalypt regeneration on the floodplain. Sheep in particular have been observed to restrict Black Box regeneration (Margules *et al.* 1990). Rabbits also limit eucalypt regeneration. The distribution of rabbits in the Stage IV area is uneven since they cannot burrow in the heavy clay soils of the floodplain and depend on dense shrub thickets (especially lignum) for shelter.

The artificial storage of water in lakes, small wetlands and creeks in the Stage IV area has affected vegetation locally. Excessive inundation has caused tree decline along a 3.5 kilometre reach of Coobool Creek, and in fringing vegetation at Lake Tooim. The banking of storage water in Tallys Lake has caused numerous tree deaths. Groundwater salinity is the likely cause of tree deaths on the eastern shore of Lake Tooim (Green 1994).

8.3.3. Impacts of Floodplain Management Strategy

Scott (1992) notes that riverine vegetation along the Murray River system is poorly conserved within reserves. Given this, plus the extent of clearing that has taken place and the current impacts on vegetation condition, there is an obvious need to protect existing riverine vegetation on the lower Edward-Wakool floodplain. This is especially true of Black Box woodland communities which have undergone the most extensive clearing. The threatened plant species in the area also have high priority for conservation.

Notwithstanding further analysis and landholder consultation regarding *hydraulically sensitive areas,* the strategy is likely to result in significant widening of the existing floodway. This is because, for works to remain unmodified, the analysis will need to establish that the works will not have a significant hydraulic impact during floods and that they are consistent with the planning principles of Murray REP2. An additional area of up to 2000 hectares of the floodplain may potentially be opened up to periodic flooding (a 5 to 10 per cent increase in available floodway area). This would be expected to provide new opportunities for the potential regeneration and rehabilitation of riverine vegetation, mainly Black Box woodlands. Where limited height levees are recommended by the strategy, existing land uses are likely to continue and consequently, regeneration of native vegetation in these areas is not expected.

Wherever practicable, the floodway limits follow natural drainage lines and consequently, include nearly all of the remnant riverine vegetation. This will ensure the continued exposure of this flood-dependent vegetation to a flooding regime and contribute to its long-term health and regeneration. Because of existing development, some flood-dependent vegetation is outside the floodway limits. The largest area affected in this way is Un-named Wetland 4 on Merran Creek, where about 190 hectares of Black Box woodland are excluded. This former wetland has been included in an *area of possible wetland value* (Figure 14). Options to return flooding to the area (and therefore to enhance the condition of the Black Box) will be explored when the licence application for works blocking flows to it is assessed.

Vegetation Management

The strategy will facilitate the regeneration of native floodplain vegetation in areas returned to flooding and will ensure that existing flood dependent vegetation within the floodways continues to be exposed to the flooding regime. Future management of vegetation within the floodways will be guided by the Western Riverina Regional Vegetation Management Plan which is currently in the early stages of preparation. The plan will complement vegetation controls already in place under Murray REP2. Importantly, the plan will enable the community to have input so that adopted vegetation management measures are practical and reflect local conditions.

Threatened Species

Section 5A of the *EPA Act* sets out those factors to be considered ("the eight part test") in deciding whether there is likely to be a significant effect on threatened species. If this test indicates that there is likely to be a significant effect then a Species Impact Statement is required.

The "eight part test" was applied to assess the effect of the strategy on threatened plants in the Stage IV area. It is important to note that since this test was applied over the whole Stage IV area, its results are of a general nature only. Site-specific assessments of threatened species impact will also be undertaken as part of the application proposals for flood control works. The general test carried out in this strategy will be used to assist in these site-specific assessments.

The results of the general test for each species are shown at Appendix A. To summarise, the test showed that, at a broad scale, the strategy is not likely to have a significant effect on any threatened plant species or plant community that may occur in the Stage IV area. Threatened species assessed that derive ecological benefits from flooding will continue to be exposed to periodic flooding through implementation of the strategy. Species that are not flood -

dependent will not be affected by the strategy. Implementation of the strategy may facilitate an expansion of suitable habitat for some of the species by potentially restoring a flooding regime to an area of up to 2000 hectares of floodplain and to 18 wetlands (80 hectares).

8.4. Fauna

8.4.1. Description

There have been no systematic fauna surveys of the Stage IV area, however, recorded observations indicate that the area supports a diverse range of species. Information in the Atlas of NSW Wildlife computer database (NPWS 1996), surveys undertaken by NSW Fisheries in 1994, a preliminary survey carried out by Atkins (1994) and observations by the Mid - Murray Field Naturalists Club, show that the following breakdown of recorded native species is known to occur in the area:

- 170 bird species (including 63 waterbird species)
- nine reptile species
- seven frog species
- seven mammal species
- four fish species

A list of native fauna species observed in the Stage IV area is shown at Appendix B. This list is not exhaustive and it is likely that further surveys would show that more species are present. Based on the known distribution of fish species, NSW Fisheries (pers. comm) advise that a further eight native fish species are likely to occur in the lower Edward-Wakool River system. These species are also listed at Appendix B.

Generally, flooding has a strong link to the life cycles of many of the animal species found in the Stage IV area. The release of nutrients from the floodplain and the emergence of aquatic invertebrates and flora following flooding stimulates breeding in many species of waterbirds. They react to the increased availability of food (Helman and Estella 1983). Wetlands in the area support waterbird breeding populations during floods. Dispersed breeding of ducks, swans, grebes and herons has been observed in the nearby Poon Boon Lakes during floods. Cormorant nesting has been observed on Coobool Creek, at Tallys Lake, and at Un-named Wetland 10 on Merran Creek. Tallys Lake also supports egret nesting.

The breeding cycle of native fish found in the Stage IV area is also strongly tied to the flooding regime. The general model of fish reproduction is that fish spawn just before or during a flood, the freshly inundated floodplain releases nutrients, and the resulting plankton growth provides a food source for larval fish. Contrary to what was previously thought, there is evidence to

suggest that fish and their larvae remain within watercourses and do not spawn or feed on the floodplain (Gehrke 1991, McKinnon 1993). The floodplain nonetheless provides an essential food supply for larval fish (Kaiela Fisheries Research Station Shepparton, pers. comm).

Riverine forest and woodland provide important nesting sites and other essential habitat for water and forest birds as well as for arboreal mammals in the Stage IV area. A range of tree age classes is necessary to maximise habitat opportunities (Helman and Estella 1983). The continuous riverine forest and woodland along the Wakool River in the Stage IV area is an important corridor for wildlife.

A check of recorded species against the Schedules of the *Threatened Species Conservation Act (1995)* shows that there are three threatened species (birds) that have been observed in the Stage IV area:

- Blue-billed Duck *Oxyura australis*. Breeds primarily in lignum swamps. This duck has been observed to migrate annually to the large, open wetlands of the Murray River in winter. The species is reportedly declining due to the adverse effects of irrigation on lignum swamps (Maher 1988).

- Freckled Duck *Stictonetta naevosa*. Breeds in extensive, dense lignum and cumbungi swamps. Also inhabits large, open lakes and their shores. Thought to be declining due to the adverse impacts of irrigation on lignum swamps (Maher 1988).

- Regent Parrot *Polytelis anthopleplus*. A breeding colony has been recorded near the junction of Wee Wee Creek and the Murray River (Brady *et al.* 1991). The parrot makes nests in hollow old River Red Gums near stands of mallee. It feeds primarily in mallee. The clearing of mallee for agriculture and the invasion of nests by the Honey Bee are known to have contributed to its decline (Garrett 1992).

Based on habitat requirements and known distributions as described in NPWS (1995), it is possible that a further 23 threatened species may occur within the Stage IV area. These species are included in Table 8.1 which lists threatened species known to occur and those that may occur in the study area.

Table 8.1 Threatened Fauna of the Stage IV Area

Recorded Species:	
Blue-billed Duck	*Oxyura australis*
Freckled Duck	*Stictonetta naevosa*
Regent Parrot	*Polytelis anthopeplus*
Species predicted to occur:	
Green and Golden Bell Frog	*Litoria raniformis*
Spotted-tailed Quoll	*Dasyurus maculatus*
Koala	*Phascolarctos cinereus*
Little Pied Bat	*Chalinolobus picatus*
Greater Long-eared Bat	*Nyctophilus timeriensis*
Australasian Bittern	*Botaurus poiciloptilus*
Magpie Goose	*Anseranas semipalmata*
Square-tailed Kite	*Lophoictinia isura*
Black-breasted Buzzard	*Hamirostra melanosternon*
Grey Falcon	*Falco hypoleucos*
Brolga	*Grus rubicundus*
Bush thick-knee	*Burhinus magnirostris*
Painted Snipe	*Rostratula benghalensis*
Black-tailed Godwit	*Limosa limosa*
Great Knot	*Calidris tenuirostris*
Red-tailed Black Cockatoo	*Calyptorhynchus magnificus*
Pink Cockatoo	*Cacatua leadbeateri*
Superb Parrot	*Polytelis swainsonii*
Swift Parrot	*Lathamus discolor*
Masked Owl	*Tyto novaehollandiae*
Gilbert's Whistler	*Pachycephala inornata*
Painted Honeyeater	*Grantiella picta*
Pied Honeyeater	*Certhionyx variegatus*

Trout cod *(Maccullochella macquariensis)*, which is listed as an endangered species on the schedules of the *Fisheries Management Act (1994)* and Silver Perch *(Bidyanus bidyanus)*, which is a potentially threatened species may also occur in the Stage IV area. The decline of trout cod in the Murray River system has probably resulted from angling pressure, the impact of introduced fish, and de-snagging (NSW Fisheries pers. comm.). These pressures, as well as the impacts of river regulation, have also contributed to the decline of silver perch.

Six of the recorded waterbird species (Greenshank, Great Egret, Sacred Ibis, White-bellied Sea Eagle, Caspian Tern and the Marsh Sandpiper) are considered to be significant. They are listed under the *China-Australia*

Migratory Bird Agreement (CAMBA) or the *Japan-Australia Migratory Bird Agreement (JAMBA)*. Additionally, two of the threatened bird species predicted to occur in the Stage IV area (Great Knot and Black-tailed Godwit) are listed under these agreements. Australia has made a commitment with China and Japan to protect the species and their habitats.

Feral foxes, pigs and rabbits occur on the floodplain. The European carp (*Cyprinus carpio*) is common in the watercourses and permanent or semi-permanent wetlands of the Stage IV area. Other introduced fish occurring in the area include redfin perch, goldfish and gambusia.

8.4.2. Impacts of Floodplain Management Strategy

The floodplain management strategy will open up an increased area of floodplain to periodic flooding. The benefit of this additional floodplain storage to fauna will depend largely on the type of land use adopted in this area. Benefits to fauna will be maximised if areas returned to a flooding regime are allowed to revert to a state approaching natural conditions. These areas will increase available nutrients during floods, enhance plankton production and provide food for waterbird and native fish populations. The regeneration of River Red Gum and Black Box woodland in these areas will increase habitat opportunities for forest and water birds as well as for arboreal mammals. Overall, an increase in biodiversity on the floodplain would be expected. The inundation of land under exotic crops or pasture, however, may lead to water quality problems. This vegetation does not tolerate extended flooding and its breakdown leads to rapid de-oxygenation of the water with harmful effects on fish and aquatic invertebrates (McKinnon 1995).

Threatened Species

Section 5A of the EPA Act sets out those factors to be considered ("the eight part test") in deciding whether there is likely to be a significant effect on threatened species. If this test indicates that there is likely to be a significant effect then a Species Impact Statement is required.

The "eight part test" was applied to assess the effect of the strategy on threatened fauna in the Stage IV area. It is important to note that since this test was applied over the whole Stage IV area, its results are of a general nature only. Site-specific assessments of threatened species impact will also be undertaken as part of the application proposals for flood control works. The general test carried out in this strategy will be used to assist in these site-specific assessments.

The results of the general test for each species are shown at Appendix C. To summarise, the test showed that, on a broad scale, the strategy would not be expected to have a significant effect on the threatened fauna. The threatened

species assessed occur in habitats that derive ecological benefits from flooding. Any existing habitat that is currently exposed to periodic flooding is included within the boundaries of the floodway, that is, the area of the floodplain where control works will only be permitted following a detailed assessment of impact. As a result, the strategy will enable these benefits to be maintained with no significant effect on any of the threatened species. As well, the strategy may facilitate an expansion of suitable habitat by restoring a flooding regime to a potential area of up to 2000 hectares of floodplain and to 18 wetlands (80 hectares).

To date, no areas of core habitat as specified under the *Koala Habitat Protection Policy (1995)* have been identified in Wakool Shire. If such areas are identified in the Stage IV area, an approved plan of management will be required in accordance with the policy. Council's determination of any development application in areas of core koala habitat will need to be consistent with this plan of management.

Fish

The strategy should not adversely impact on any trout cod or silver perch populations in the area. The increase in inundated floodplain, including the potential restoration of 80 hectares of wetlands along Merran Creek and the Wakool and Murray Rivers, is expected to benefit fish populations by increasing food supply during floods.

Block banks on ephemeral streams in the study area are likely to impede fish passage during floods. The strategy has recommended the lowering of block banks in the storage area between Gum Creek and the Wakool River, and on Coobool Creek upstream of the junction with the Wakool River, to regulated flow height. This is expected to benefit fish by improving conditions for passage through these areas during floods.

Elsewhere, the strategy has retained existing block banks because they are at a low level and have a minimal effect on flooding or protect substantial areas of developed land from flooding. These banks, however, have the potential to adversely impact on migrating fish. Native fish species tend to migrate mostly when river levels are rising, and tend to follow creek lines or flood-runners rather than moving across the broad floodplain. Relatively small rises in river level may initiate a large - scale migration response. While the impact of block banks may be insignificant during major floods when the banks are drowned out, the impact may be severe during small to moderate floods. Further, the retention of block banks is inconsistent with the planning principles of Murray REP2 regarding the benefits to riverine ecosystems of periodic flooding, the avoidance of adverse effects on the quality of aquatic habitats and the minimisation of disturbance to the shape of streambanks.

In order to address these issues, options for improving fish passage will be explored on an individual basis when licences for these block banks under the *Water Act* are assessed or renewed. These environmental assessments will be referred to NSW Fisheries for their consideration. Under the *Fisheries Management Act*, NSW Fisheries must be notified if a block bank is to be constructed or altered, or if a public authority proposes to approve a block bank.

Waterbirds listed under JAMBA and CAMBA

The strategy will facilitate the protection of habitats for the six recorded waterbird species listed under JAMBA and CAMBA since these habitats are contained within the floodway and are likely to be expanded given the potential for the regeneration of riverine vegetation. Similarly, implementation of the strategy will enable the habitats of the Great Knot and the Black-tailed Godwit, which are listed species predicted to occur in the study area, to be protected.

Introduced animals

The expected regrowth of native vegetation in areas returned to flooding would have overall environmental benefits and would enhance habitat opportunities for a range of native fauna. Although the increased cover may improve conditions for feral animals, including pigs and rabbits, significant increases in numbers would not be expected. The Rural Lands Protection Board is available to assist with the control of noxious animals.

Implementation of the strategy would not be expected to cause an increase in populations of introduced fish. It will enhance conditions for native fish and would not be expected to create additional opportunities for European carp.

There is a range of claims regarding the impact of carp on river degradation, however most of these are unsubstantiated. Recent research supports claims that carp are adversely affecting aquatic habitats by increasing turbidity and uprooting certain species of water plants (Roberts and Tilzey 1997). There is no direct scientific evidence linking carp with the undermining of streambanks, subsequent loss of riparian vegetation and changed channel capacity.

8.5. Groundwater

The Stage IV area is located in the central part of the Murray Geological Basin. The basin has a closed nature and there is no outlet to release excess groundwater. Consequently, there are major groundwater discharges towards the surface. The Wakool Irrigation District, which borders the Wakool River to the north of the Stage IV area, has a major groundwater discharge component. The area affected by shallow watertables has been increasing in

recent times. Groundwater in the Wakool Irrigation District is generally highly saline and rising watertables pose a threat to agricultural production (Wakool Community 1995). Within the Stage IV area, there is evidence of localised, shallow, saline watertables near Lake Tooim and the Poon Boon Lakes system.

Flooding on the Edward - Wakool floodplain has an important influence on groundwater. By ponding water over large areas for periods of weeks or months, flooding creates a hydraulic head and recharges the watertable. The main factors controlling recharge are the resident time of inundation, the hydraulic loading, and the soil texture. Groundwater accession mainly occurs where light - textured soils prevail. A study of the hydrogeology of the Wakool Irrigation District prepared by Bogoda *et al.* (1994) showed that groundwater meters in floodplain areas can have a significant response to flooding. The groundwater mound built up during the 1974 floods was up to 3 metres thick. The 1992 flood created a groundwater recharge mound of 108,000 ML that was up to 2 metres thick.

The strategy will return additional floodplain areas (potentially up to 2000 hectares) to flooding. The flooding of these areas is likely to cause an increase in recharge and possibly some rises in the groundwater directly below. However, it is not possible to predict the extent of these rises without detailed modelling and a knowledge of possible changes to land use. For example, regrowth of native vegetation in areas returned to flooding would act to offset increases in recharge, although this may take 5 to 10 years to take effect. The increased inundation may be beneficial for those areas prone to shallow watertables and hence salinity problems. The flooding of these areas is expected to reduce soil salt levels by flushing additional salts from the soil surface and by leaching salts through the soil profile.

8.6. Surface Water Quality

The release of flood flows from limited height levee areas that have been overtopped during large floods is not expected to adversely impact on water quality. It is expected that floodwaters would be contained within these levees for a maximum period of three or four days. Deoxygenation effects from the breakdown of inundated exotic pastures (Section 8.4.2) would be expected to be minor during this time. Nutrient levels transported from the inundated area to the stream system would not be expected to differ significantly from levels already in the system. Sediment would be deposited within the leveed area and consequently, there would be no net increase in sedimentation in the stream system. Return flows would be of low velocity and would not be expected to cause bank erosion along the stream system. Overall, water quality impacts would be expected to be minor and would occur infrequently since the levees would be overtopped by flood flows larger than 20 year ARI.

The widening of floodways at sites where flood flows are currently constricted will reduce the likelihood of scour caused by high velocities. As a result, turbidity levels and nutrient loadings downstream of these sites may be reduced.

8.7. Aboriginal Heritage

The lower Edward-Wakool floodplain is located within a region that had one of the largest Aboriginal populations in Australia and still contains one of the richest and most diverse suites of archaeological sites known. The Aboriginal occupants of the floodplain were essentially riverine people whose resources were largely derived from the well-watered parts of the landscape such as rivers, creeks and wetlands (Hughes and Berryman 1985).

The National Parks and Wildlife Register records 176 Aboriginal sites in the broad riverine area between Swan Hill and the Wakool Junction. These sites have been listed mainly from random assessments. There have been few systematic archaeological research projects undertaken in the region (NPWS pers. comm). The most commonly occurring types of Aboriginal sites found on the Edward-Wakool floodplain include:

- *mounds* Earthen mounds, roughly circular in shape, that accumulated from earth and burnt clay used during cooking in oven pits. Mounds range in size from 15cms to 120cms in height. *Found on river and creek floodplains, around the margins of large wetlands and adjacent to inlet channels of lakes and swamps.*

- *scarred trees* These result from the removal of bark from trunks for use as canoes, containers, shields and shelter. Scars can be up to three metres long and one metre wide. These are the most common type of site in the riverine forests. *Found on River Red Gum and Black Box trees on river and creek banks and generally over the floodplain.*

- *burials* These sites can consist of a single burial, isolated individuals in an area or cemeteries. *Usually found in sandy deposits, such as dunes adjacent to rivers and creeks, lunettes, but are also located in mounds.*

- *shell middens* These are deposits of freshwater mussel shells. Middens can vary in size from small camps comprising a few shells to large deposits more than one metre thick. Middens can contain stone artefacts,

animal bones and remains of hearths. *Found along river and creek banks*.

- *open campsites* These consist of open scatters of stone artefacts and hearths. *Found around lakes and swamps particularly where the land is slightly elevated*.

Hughes and Berryman (1985) noted that the relatively intact wooded tracts along the major active creeks and rivers on the floodplain are of high archaeological significance. These areas contain large numbers of a wide range of sites such as scarred trees, burials, mounds and shell middens. Other especially significant areas are dunes bordering rivers and creeks, and sandy deposits at lake margins where burial sites tend to occur. Beyond the rivers and creeks, development has caused extensive disturbance to archaeological sites. Nevertheless, these disturbed sites have scientific and wider heritage value and are protected under the *NSW National Parks and Wildlife Act (1974).*

Specific areas of high sensitivity identified by Hughes and Berryman (1985) within the Stage IV area include:

- Coobool Creek — There is frequent occurrence of burial sites with human materials commonly much older than those located elsewhere in the region (some older than 20,000 years).

- Larrys Creek
Merran Creek — These areas are likely to be significant with regard to old burial sites.

- Kyalite State Forest — There is a large number of scarred trees (more than 100) over a relatively small area. This site is listed on the National Estate Register of the Australian Heritage Commission.

- Wetuppa State Forest
Liewa State Forest — These forests are likely to contain a large number and diverse range of sites.

The State Forests in the area are subject to low intensity logging. Hughes and Berryman (1985) considered this to be a low impact land use as scarred trees are not preferred for logging and middens and mounds are generally avoided by tracks and tractors.

The floodplain management strategy includes nearly all of the existing riverine woodland and forest in the Stage IV area within the floodway limits. The protection of sites of high archaeological significance within these areas

will be facilitated in this way. This is particularly relevant to the maintenance of scarred trees.

An area of 190 hectares of Black Box woodland is excluded from the floodway at Un-named Wetland 4 on Merran Creek. This woodland is included as an *area of possible wetland value*. The area will undergo environmental assessment as part of the licensing application for the associated levee bank (Section 8.2.3). The impact of this bank on any Aboriginal sites, particularly scarred trees, will be considered as part of this assessment.

An assessment of impact on Aboriginal heritage will be carried out as part of development and licensing applications for proposed and existing flood control works. This will include an assessment of impact at the proposed site of construction and any off-site impacts such as potential damage to scarred trees. Local Aboriginal land councils will be consulted as part of this assessment. These councils include the Balranald Aboriginal Land Council for the floodplain area downstream of Kyalite and the Wamba Wamba Local Aboriginal Land Council for the remainder of the Stage IV area.

8.8. Social Environment

The floodplain management strategy rationalises existing uncoordinated earthworks so that the risk of the flood wave being increased or accelerated to undesirable levels is minimised. This is an important benefit to the community since it significantly reduces the risk of catastrophic flood damage.

The implementation of the strategy, however, will incur costs. In financial terms, this cost will be borne by government agencies when modifying works as required by the strategy, and by landholders when modifying their works or preparing hydraulic or environmental assessments for them. Additionally, where works are modified, landholders may incur lost agricultural production as land is returned to a flooding regime. There may be more frequent loss of access during floods where private roads have been included in *hydraulically sensitive areas*. Landholders in these areas may suffer increased inconvenience during floods. This impact is not considered to be excessive since the analysis has shown that existing roads in these areas are too high and have the potential to increase flood damage by raising the level of localised flood water.

It is important to note that funding opportunities under the Commonwealth *Natural Heritage Trust* may be available to offset the cost of modifying earthworks consistent with the strategy. Details on these funding opportunities are outlined below (Section 9).

The strategy recommends causeways across Officers Road (250 metres), Fountains Road (250 metres), Noorong Road at Coobool Creek (800 metres) and MR 386 near Coonamit Bridge (900 metres). Officers Road and Fountains Road are local council roads with daily usage of about 50 and five vehicles respectively. An average of 250 vehicles use Noorong Road and 350 use MR 386 daily (Wakool Shire Council pers. comm). The proposed causeways are trafficable but may cause some inconvenience by slowing traffic flow. This impact will be greatest on MR 386 since this road is largely flood-free and has the highest traffic usage. The causeways will help to limit flood damage by minimising the build up of floodwaters upstream of the roads. The impacts of the causeways on traffic flow, therefore, are considered to be minor. While the strategy will enable access along main roads in the study area during minor and moderate-sized floods, during major floods this access cannot be guaranteed. Emergency services during these events may need to be carried out by boat or by air.

Without implementation of the strategy, large floods on the floodplain will have substantial economic and social impacts. Moderate and major flooding within the existing levee network will not be predictable and is likely to cause widespread damage to public and private property. The floodway system has been designed so that the risk of damage from flooding up to the magnitude of the 1956 flood is minimised. However, it is important to note that the risk of more extreme floods occurring will always be present. In this event, uncontrolled flooding would be expected.

The floodway design has been based on hydraulic assessment as well as on environmental, economic and social factors. Community responses to the draft strategy have been carefully considered and the strategy amended accordingly. By including private flood control works in *hydraulically sensitive areas*, the strategy provides scope for landholders to consult with DLWC regarding practical options that may address hydraulic impacts. Similarly, the strategy sets up a process whereby landholders with *areas of possible wetland value* can consult with DLWC to explore, within legal constraints, options for enhancing the ecology of these areas. Overall, the strategy is considered to be equitable and its implementation is not considered to cause undue disadvantage to individual landholders or to the local community.

8.9. Alternatives to the Proposed Management Strategy

Maintenance of Existing Development

The existing arrangement of levees, channel banks, roads and the railway line on the floodplain is uncoordinated and constricts flood flows. Consequently while some landholders have flood protection, others can be disadvantaged because the constriction of flows has artificially raised the level of localised floodwaters. This occurred during the 1993 flood when

flows were smaller than the 1956 flood. Because of development on the floodplain, it reached significantly higher levels on the Wakool River in the upstream part of the study area than it did in 1956.

If existing development on the floodplain was maintained, the passage of moderate and major floods through the study area would be disorderly, leading to extensive damage to public and private property. Current restrictions on floodplain storage would also continue to limit the potential environmental benefits of flooding, including nutrient cycling, the sustenance of fish and waterbird populations, and the restoration of wetlands. Overall, the disadvantages associated with this alternative are considered to be unacceptable.

Continued Uncoordinated Levee Development

Continued uncoordinated levee development would further constrict flood flows and increase the existing problem of uncontrolled flooding. Flood levels would be increased and the flood wave accelerated, leading to widespread flood damage. Ultimately, the constriction of flood flows through the study area would accelerate the flood wave dangerously, with potential catastrophic effects downstream. The further restriction of floodplain storage would reduce the environmental benefits of flooding to wetlands, soils, fauna and floodplain vegetation. For these reasons, this alternative is considered unacceptable.

No Levees

The removal of existing levees and channel banks to natural surface would restore a flooding regime to large areas of the floodplain. Over time, and with environmentally sympathetic land management in these areas, this would be expected to produce a range of ecological benefits. These include the restoration of wetlands, regeneration of floodplain vegetation, increased habitat opportunities for floodplain fauna and increased biodiversity. Restored flooding would also benefit soils by increasing its moisture and nutrient status. Economically, there would be benefits from increased opportunities for summer cropping and potential for fisheries. The rehabilitation of floodplain ecosystems would enhance opportunities for eco-tourism and other recreational activities.

The removal of existing flood control works would generate, however, substantial economic costs to the community, particularly during major floods. Given the extent of existing development and current land uses, this alternative would significantly decrease the options for a secure livelihood to many landholders in the Stage IV area. Those most affected would be the relatively small landholders without suitable areas of flood-free land for relocating stock or for carrying out alternative farming practices.

Additionally, there would be widespread damage to houses, other property and farm infrastructure.

Overall, this scenario (while having a number of ecological and associated economic benefits) would have a significant adverse impact on the livelihood of individual landholders. For this reason, it is considered to be an unacceptable alternative to the proposed strategy.

8.10. Summary of Environmental Impacts

Implementation of the strategy is likely to result in significant widening of the existing floodway. It is expected to return an additional land area of up to 2000 hectares to periodic flooding and increase the floodway area by between five and ten per cent across the floodplain. A further 2200 hectares will be exposed to floods larger than the 1993 flood. A number of environmental benefits and impacts associated with these changes have been identified.

Soils

Flooding will contribute sediment, nutrients and moisture to the soils in this area and accordingly, will benefit soil structure and condition. As a safeguard against potential soil erosion resulting from poorly constructed flood control works, landholders will be issued with a set of guidelines for the construction and maintenance of rural levees when works are licensed.

Vegetation

There will be new opportunities for the regeneration of riverine vegetation (mainly Black Box woodlands) in the area exposed to more frequent flooding. With increased agricultural development, Black Box has been extensively cleared from the floodplain. Its conservation is important. The floodway follows natural drainage lines as far as practicable, and includes nearly all of the existing riverine vegetation within its limits. As a result, the strategy will ensure that this flood-dependent vegetation is exposed to a flooding regime. A notable exception is an area of Black Box woodland at Un-named Wetland 4 on Merran Creek that has been excluded from the floodway. This former wetland has been included in an *area of possible wetland value* (Figure 14). Options to return flooding to the area (and therefore to enhance the condition of the Black Box) will be explored when the licence application for works blocking flows to it is assessed.

The test for significant effect on threatened species, populations and communities was applied to assess the effect of the strategy on six species of threatened plants that have potential habitat in the Stage IV area, in accordance with *Section 5A of the EPA Act*. This test showed that the strategy would not have a significant effect. All potential existing habitats

that are currently exposed to or benefit from periodic flooding, are included within the boundaries of the floodway.

Wetlands

There are 515 small wetlands and 12 wetlands larger than 50 hectares in the study area. Agricultural development has modified the hydrology of some of the wetlands that have been blocked off for cultivation or are now used for water storage. These wetlands are economically significant to landholders but have a reduced ecological value. Functional wetlands have important conservation value since they support high species diversity and biological production. Wherever practicable, wetlands have been included within the floodway limits so that a flooding regime is ensured.

Because of potential high economic and social impacts, 7 large and 26 small former wetlands that have been blocked from flooding are not included in the design floodway. These have been mapped as *areas of possible wetland value*. This means that when flood control works affecting these areas are assessed for licensing purposes, or when government agencies plan modifications to these works, options for the return of flooding will be explored. The ecological value of the *areas of possible wetland value* varies throughout the floodplain and accordingly, the potential for rehabilitation is also variable.

The strategy is expected to restore a more natural flooding regime to 18 small wetlands with a combined area of 80 hectares. The ecological value of these wetlands should be enhanced as a result. Additionally, two large wetlands on Merran Creek will be exposed to floods of 5 year ARI and larger, thereby enhancing the productive capacity of these wetlands.

Fauna

The floodplain supports a range of fauna including many flood-dependent species. Six waterbird species listed under JAMBA and CAMBA, and three threatened bird species have been observed in the study area. A further 23 threatened species of fauna, including two species listed under JAMBA and CAMBA, are also predicted to inhabit the area. The test for significant effect on threatened species, populations and communities was applied, in accordance with *Section 5A of the EPA Act*. It showed that, subject to further assessment of specific works applications, implementation of the strategy would not be expected to have a significant effect on threatened fauna. The strategy will maintain a flood regime to existing habitats and enable the ecological productivity of the habitats to be maintained. The expected increase in inundation will provide for potential regeneration of native vegetation. It is expected to benefit fish, including the endangered Trout Cod and potentially threatened Silver Perch, as well as waterbird populations by

increasing food supply during floods. It is also likely that habitat opportunities for forest bird and mammal species will be increased.

The strategy has retained a number of existing block banks within the floodway because have a minimal effect on flooding and are economically important to landholders. These banks, however, have the potential to adversely impact on migrating fish. Further, the retention of the block banks is inconsistent with the planning principles of Murray REP2 relating to land degradation, bank disturbance and the benefits to riverine ecosystems of periodic flooding. In order to address these issues, the strategy sets out a process of further environmental assessment for block banks so that options for improving fish passage can be explored on an individual basis when licences are assessed or renewed (*Water Act*). The assessments will be referred to NSW Fisheries for their consideration.

Groundwater

By returning additional floodplain areas to flooding, the strategy is likely to cause an increase in groundwater recharge and possibly some rises in the groundwater directly below. It is not possible to predict the extent of these rises, however, without detailed modelling and a knowledge of possible changes to land use. The increased inundation may be beneficial for those areas prone to shallow watertables and hence, salinity problems. Flooding of these areas is expected to reduce soil salt levels by flushing additional salts from the soil surface and by leaching salts through the soil profile.

Aboriginal Heritage

The lower Edward-Wakool floodplain once supported a large Aboriginal population that derived its resources from the well-watered parts of the landscape. The relatively intact riverine forests and woodlands along the major active streams are of high archaeological significance, containing a range of Aboriginal sites. Existing riverine vegetation is largely contained within the floodway limits. The protection of sites (especially scarred trees) in these areas will be facilitated. An exception is at Un-named Wetland 4 on Merran Creek which has been mapped as an *area of possible wetland value*. The assessment of this area for licensing purposes will include an analysis of impact on any Aboriginal sites.

Social Environment

There will be costs associated with implementing the strategy. These include the financial costs of modifying or removing flood control works, the costs of carrying out any hydraulic or environmental assessments, losses in agricultural production on land returned to flooding and reduced access for some landholders during floods. Funding opportunities under the *Natural*

Heritage Trust may offset the cost to landholders of implementing on - ground works consistent with the strategy.

The cost of not implementing the strategy will ultimately be significant since the potential for flood damage within the existing levee network is high. Recommended causeways on local council and regional roads will slow traffic flow locally during floods. This impact is considered to be minor relative to the hydraulic benefits of the causeways.

Site Specific Assessment

Site specific environmental assessments, as required under the *EPA Act,* will be carried out when development or licensing applications for flood control works are made. The environmental assessment in the strategy will be used to assist in this assessment. Additionally, the strategy sets out a process for evaluating *areas of possible wetland value* and determining the level of detail to be included in their environmental assessment. The strategy also sets up a process of further environmental assessment for block banks that affect fish passage. Subject to further environmental assessment, implementation of the strategy is not expected to have significant environmental impacts.

8.11. Requirements for Further Environmental Assessment

Areas of Possible Wetland Value

Environmental assessment under *Part 5 of the EPA Act* is required when existing flood control works, constructed before the gazettal of Murray REP2, are assessed for licensing or licensing renewal purposes. The strategy has identified *areas of possible wetland value* so that they are specifically considered when works affecting flows to the areas are assessed. DLWC will carry out an evaluation of the environmental significance of each area which will determine the level of detail required in the assessment. Within the context of legal requirements, DLWC will take a co-operative and pragmatic approach in exploring options to return seasonal flooding to *areas of possible wetland value*. The process for environmental assessment is detailed in Section 8.2.3.

Existing government - owned flood control works (roads and railway embankments) do not require licensing under the *Water Act* and therefore, do not trigger an environmental assessment for licensing purposes. The strategy maps highlight these works where they affect flows to *areas of possible wetland value* so that relevant agencies can consider the areas when planning modifications to the works.

The location of *areas of possible wetland value* is summarised in Table 8.2 below.

Table 8.2 Areas of Possible Wetland Value

Stream	*Name / Pressey No.*	*Figure*
Waddy Creek	Old Waddy Creek	14
Mulligans Creek	1410, 1408, 1409	14
	1411, 1407 (Part) Un-named Wetland 2	
Larrys Creek	1422	14
Merran Creek	1434	14
	Wilsons Lake (1433)	
	Un-named Wetland 4	14
	Un-named Wetland 10 (Part)	18
	Un-named Wetland 11	18
	Un-named Wetland 12	18
Wakool River	1390 (Part), 1339 (Part), 1421	14
	1221, 1222	15
	180, 182, 179, 192	17
	193,194,195	17
	Un-named Wetland 39	
	Un-named Wetland 76	
	Un-named Wetland 80	
	Un-named Wetland 43	17
	Un-named Wetland 40	17
Cunninyeuk Creek/Niemur River	1052, Un-named Wetland 56, 1151	15
Edward River	Lake Talbetts, Forest Creek	17
	Un-named Wetland 79	16

Block Banks

Environmental assessment under *Part 5 of the EPA Act* is required when existing block banks, constructed before the gazettal of Murray REP2, are assessed for licensing or licensing renewal purposes under the *Water Act*. Licensing is under *Part 2 of the Water Act* if the bank is used primarily for water storage. As part of the environmental assessment, options for improving fish passage will be explored on an individual basis. Environmental assessments for block banks will be referred to NSW Fisheries for their consideration. Under the *Fisheries Management Act*, NSW Fisheries must be notified if a block bank is to be constructed or altered, or if a public authority proposes to approve a block bank. The location of block banks in the Stage IV area is summarised on Table 8.3 below.

Table 8.3 Block Banks

Associated Stream	*Figure*
Waddy Creek	14
Mulligans Creek	14
St Helena Creek	14
Larrys Creek	14
Wakool River	14 - 18
Coobool Creek anabranch	14
Coobool Creek	14, 15
Box Creek (downstream of Tallys Lake)	14
Un-named Creek between Coobool Creek and Gum Creek	14
Merran Creek	14
Mallan Mallan Creek	15

9. FUNDING OPPORTUNITIES

Funding opportunities through the Commonwealth *Natural Heritage Trust* may be available to assist landholders in modifying flood control works according to the strategy's requirements. Specifically, *Murray - Darling 2001* and the *National Landcare Program* may be relevant. The purpose of the *Murray - Darling 2001* program is to implement on - ground action in the Murray - Darling Basin to achieve the following objectives:

- improving the health of key river systems,
- encouraging ecologically and economically sustainable land use,
- restoring riverbank land systems, wetlands and floodplains;
- improving water quality.

The *National Landcare Program* supports collective action by communities to sustainably manage the environment and natural resources in partnership with government.

Under both programs, successful funding applications would demonstrate that the primary aim of the project is natural resource management. Successful funding applications would need to demonstrate that the on - ground works or activities:

- are consistent with a regional or catchment management plan,
- form part of an approved action plan,
- are central to the achievement of the plan's objectives,
- are of strategic importance,
- provide significant public benefit,
- have community ownership.

For the purposes of the funding programs, the Edward - Wakool Floodplain Management Strategy would be considered as an approved action plan that has community ownership. At a regional scale, the strategy is consistent with Murray REP2.

It is important that landholders interested in applying for funding do so through an incorporated community group. One or two co-ordinated submissions are more likely to be successful than many small and inconsistent applications.

Funding is determined on the basis of negotiated cost sharing arrangements. In general, applicants are expected to contribute at least one dollar (in cash or kind) for every one dollar provided by Trust funds. The contribution by applicants can include labour, equipment and machinery use. *Natural Heritage Trust* funds are not available for the purchase, lease or acquisition of land, or to compensate for lost agricultural production.

10. IMPLEMENTATION OF THE STRATEGY

Given the extent of activities outlined in the strategy, a structured approach to implementation is proposed. The *Central Murray Floodplain Working Group* will have a key role in overseeing the implementation. This group, which has been formed under the auspices of the Central Murray Floodplain Management Committee, comprises DLWC and community representatives. It will be active in consulting with landholders to implement actions consistent with the strategy. The group will also periodically review the progress of the strategy's implementation against specific targets. Further targets and actions would be planned according to the outcomes of this review.

As a preliminary target, 25 per cent of actions outlined in the strategy should be implemented within two years of the release of the strategy. Progress will be reviewed at that time. Overall implementation of the strategy is expected to take about 10 years.

The working group will commence the implementation at the downstream end of the Stage IV area and work progressively upstream along component river reaches of the floodplain. The group will focus on carrying out the strategy's requirements for *hydraulically sensitive areas* as a priority. This will include overseeing the implementation of workable solutions that are available in some of the *hydraulically sensitive areas*.

DLWC will set targets for undertaking assessments of works associated with *areas of possible wetland value* as well as block banks. The processing of license applications for all unlicensed works is a requirement of this strategy and will be incorporated within the implementation plan.
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11. REFERENCES

Atkins, B. (1994) *Poon Boon Lakes - a preliminary survey of aquatic communities.* Draft Report for the NSW Department of Water Resources, Murray Region.

Australian Nature Conservation Agency. Thackway, R. & Creswell, I.D. (eds) (1995) *An Interim Biogeographic Regionalisation of Australia.*

Barker, R. D. and Vestjens, W. J. M. (undated) The Food of Australian Birds Volume 2 Passerines. CSIRO Division of Wildlife Ecology.

Blakers, M.,Davies, S.J.,Reilly, P.N. (1984). *The Atlas of Australian Birds*. Royal Australian Ornithologists Union.

Bogoda, K.R., Kulatunga, N. & Hehir, K. (1994) *Overview of Hydrogeology and Assessment of Subsurface Drainage Option for Watertable Control in Wakool.* Draft Number 1. Internal Document (Department of Water Resources).

Brady et al (1991) *Draft Report of the New South Wales Murray Wetlands Working Group.* Technical Services Division, NSW Department of Water Resources.

Briggs, S.V. (1990) Waterbirds. pp. 337-344 in *The Murray* (eds. Mackay, N. and Eastburn, D.). Murray-Darling Basin Commission.

Briggs, S.V. (1994) *The Ecological Management of Lakebed Cropping*.

Burton, J., Junor, R. & Whitehouse, G. (1995) *Resolving the Floodplain Management Issues in the Central Murray Region of NSW*. NSW Floodplain (Non-Tidal) Management Advisory Committee

Butler, B.E., Blackburn, G., Bowler, J.M., Lawrence, C.R., Newell, J.W. & Pels, S. (1973) *A Geomorphic Map of the Riverine Plain of South-eastern Australia.* Australian National University Press, Canberra.

Cogger, H. G. (1994) *Reptiles and Amphibians of Australia*. Fifth edition. Reed Books, Sydney.

Cunningham, G.M., Mulham, P.L., Milthorpe, P.L. & Leigh, J.H. (1981) *Plants of Western New South Wales*. Soil Conservation Service NSW.

Dalton, K. (1989) *Rangeland Review Southern Riverine Woodlands.* Soil Conservation Service of NSW. Technical Report Number 15.

Department of Land and Water Conservation (1996) *Threatened Plants Database.*

Department of Land & Water Conservation (1996) *The NSW Wetlands Management Policy.* NSW Government.

Department of Planning (1994) *Murray Regional Environmental Plan Number 2 - Riverine Land.* NSW Government.

Department of Water Resources (1989) *Guidelines for Edward and Niemur Rivers Floodplain Development - Moama-Moulamein Railway to "Liewah".*

Dickman, C. R., Pressey, R. L., Lim, L., and Parnaby, H. E. (1993) Mammals of Particular Conservation Concern in the Western Division of New South Wales. *Biological Conservation* Volume 65, pp. 219-248.

Frith, H. J. (1977) *Waterfowl in Australia.* A. H. & A. W. Reed Pty. Ltd.

Garrett, S. (1992) *The Action Plan for Australian Birds.* Australian National Parks and Wildlife Service Endangered Species Program. Project Number 121.

Gehrke, P.C. & McLean, P. (1988) *Report of a Preliminary Survey of Fish Communities at 14 Wetlands associated with the River Murray.* NSW Agriculture and Fisheries Internal Report.

Gehrke, P.C. (1991) Avoidance of Inundated Floodplain by Larvae of Golden Perch (Macquaria ambigua): Influence of Water Quality or Food Distribution? *Australian Journal of Marine and Freshwater Research* Volume 42, pp 707-719.

Green, D.L. (1994) *Wetland Requirements and River Operations in the Murray Region.* NSW Department of Water Resources.

Harper, M. J. 1990 The Re-establishment of Magpie Geese at Bool Lagoon, South Australia. South Australian Ornithologist Volume 31 pp. 44-47.

Helman, P. & Estella, P. (1983) *The Conservation Status of Riverine Ecosystems in Western New South Wales.* State Pollution Control Commission NSW.

Hughes, P.J. and Berryman, A. (1985) *Aboriginal Resources Planning Study for the Wakool Shire Council, NSW.* ANU Archaeological Consultancies.

Johns, G.G., Tongway, D.J. & Pickup, G. (1984) in Harrington, G.N., Wilson, A.D. and Young, M.D. (eds) *Management of Australia's Rangelands.* CSIRO, Melbourne.

Kingsford, R. (1991) *Australian Waterbirds - a field guide.* Kangaroo Press, Sydney.

Lawson and Treloar Pty Ltd (1995) *Draft Swan Hill Regional Flood Strategy - Hydraulic Evaluation of Strategies.*

Lee, A. and Martin, R. (1988) *The Koala - A Natural History*. New South Wales University Press.

Lloyd, L.N., Atkins, B.P., Beovich, E.K. & Warner, A.C. (1991) *Hydrological management of mid-Murray floodplain wetlands for ecological conservation.* Victorian Department of Conservation and Natural Resources.

Lugg, A. (1993a) *Wetland Management Guidelines for Local Councils in the Murray Region.* Murray Wetlands Working Group.

McKinnon, L. (1993) Monitoring of Fish Aspects of Trial Flooding of Barmah Forest. *NRMS Fish Research - Applying the Results*. Workshop Papers. Murray-Darling Basin Commission.

McKinnon, L. (1995) Factors contributing to a Fish Kill in Broken Creek. *The Victorian Naturalist* 112 (2).

Maher, P. (1988) Threatened Avifauna of Western New South Wales with special reference to Plant Communities. *National Parks Journal* Volume 32 (4), pp 11-16.

Marchant, S.M. and Higgins, P.J. (co-ordinators) (1990) *Handbook of Australian, New Zealand and Antarctic Birds*. Volume 1 Part B Pelican to Ducks. Oxford University Press.

Marchant, S.M. and Higgins, P.J. (co-ordinators) (1993) *Handbook of Australian, New Zealand and Antarctic Birds*. Volume 2 Raptors to Lapwings. Oxford University Press.

Margules and Partners Pty Ltd, P. and J. Smith Ecological Consultants, & Victorian Department of Conservation Forests and Lands (1990) *River Murray Riparian Vegetation Study.* Murray-Darling Basin Commission.

Mount, T., Ross, J. & Bish, S. (1991) *Impact of Floodplain Management Schemes on Groundwater Recharge, Lower Namoi Valley.* Technical Services Division, NSW Department of Water Resources.

Murray-Darling Basin Commission (1993) *River Murray Mapping.* Digital orthophotos.

Murray-Darling Basin Commission (1996) *River Murray Mapping.* Digital wetlands data.

National Parks and Wildlife Service, NSW (1982) *Contribution to Local Environmental Study Wakool Shire.*

National Parks and Wildlife Service, NSW (1995) *Endangered Fauna of Western New South Wales.* Compiled by D. Ayers.

National Parks and Wildlife Service, NSW (1996) *Atlas of NSW Wildlife Computer Database*. GIS Division.

Naunton, D. (1995) *Economic Assessment of Floodplain Management.* Wakool Land and Water Management Plan.

NSW Government (1999). *Water Quality and River Flow Interim Environmental Objectives - Murray River Catchment (NSW).*

Pizzey, G. (1980) *A Field Guide to the Birds of Australia*. Collins Publishers.

Pressey, R.L. (1986) *Wetlands of the River Murray below Lake Hume.* River Murray Commission Environmental Report 86/1.

Reader's Digest (1986) *Complete Book of Australian Birds.* Reader's Digest Press.

Richards, G. C. (1983) Greater Long-eared Bat. pp. 328-329 in *The Complete Book of Australian Mammals* (ed. Strahan, R.). Angus and Robertson Publishers.

Roberts, J. and Tilzey, R. (eds.) (1997) *Controlling Carp - exploring the options for Australia.* Proceedings of a Workshop, 22-24 October 1996, Albury. CSIRO Land and Water.

Robinson, M. (1993) *A Field Guide to Frogs*. Australian Museum, Sydney.

Scott, J.A. (1992) Vegetation of the Balranald-Swan Hill Area. *Cunninghamiana* Volume 2 (4), pp 597-653. Royal Botanic Gardens, Sydney.

Serventy, V.N. (ed.) (1985) *The Waterbirds of Australia.* The National Photographic Index of Australian Wildlife. Angus and Robertson Publishers.

Slater, P., Slater, P. and Slater, R. (1986) *The Slater Field Guide to Australian Birds*. Rigby Publishers, Sydney.

Tyler, M. (1994) in Lunney, D., Hand, S., Reed, P., & Butcher, D. *Future of the Fauna of Western New South Wales.* Transactions of the Royal Zoological Society.

Wakool Community (1995) *Wakool Community's Land and Water Management Plan.*

Water Resources Commission (1978) *Guidelines for Floodplain Development - Tuppal and Bullatale Creeks.*

Water Resources Commission (1981) *Guidelines for Edward and Wakool Rivers Floodplain Development - Deniliquin to Moama-Moulamein Railway*

Water Resources Commission (1987) *Guidelines for Murray and Wakool Rivers Floodplain Development Development - Moama-Moulamein Railway to Noorong Road.*

12. GLOSSARY

ANCA	Australian Nature Conservation Agency
Areas of possible wetland value	Areas of formerly functional wetlands, that have been blocked from flooding for agricultural or development purposes, and are situated outside the design floodway. The ecological value of these areas has been reduced but options for their future rehabilitation may be possible.
ARI	Average Recurrence Interval. A probability term defining the average of the period between exceedances of a given discharge.
CAMBA	China - Australia Migratory Bird Agreement
DLWC	NSW Department of Land and Water Conservation
EPA	NSW Environment Protection Authority
EPA Act	*Environmental Planning and Assessment Act (1979).* Environmental assessment of flood control works is required under this Act. Part 4 of the Act applies to works which require development consent under Murray REP2. Part 5 of the Act is triggered when works not requiring development consent require licensing under the Water Act.
Existing Use Rights	The situation where a flood control work may pre-date Murray REP2 and may not require development consent. Such a work would have been constructed before the gazettal of Murray REP2, would have been lawful under planning instruments in place at the time, and would have remained unmodified since construction.
Flood Control Works	Works as defined under Murray REP2 that change the natural or existing condition or topography of land and are likely to affect the hydrology of the River Murray system. These include the construction or alteration of levees, channels and mounds.

Floodplain Storage	Those parts of the floodplain that are important for the temporary pondage of floodwaters during the passage of a flood.
Floodways	Those areas where a significant volume of water flows during floods. They are often aligned with naturally defined channels. The blockage, or partial blockage, of a floodway can cause a significant redistribution of floodwaters. This, in turn, may adversely affect other areas. The floodway in the strategy has been designed to pass the equivalent flow to the 1956 flood.
Hydraulically Sensitive Areas	Areas on the floodplain where existing flood control works can significantly affect the behaviour and distribution of flood flows. Privately owned works in these areas will be the subject of further consultation and analysis. Government works in hydraulically sensitive areas will undergo specific modifications as outlined in the strategy.
JAMBA	Japan - Australia Migratory Bird Agreement
Limited Height Levees	Levees that the strategy has recommended are limited in height to the level of the 1993 flood.
MDBC	Murray-Darling Basin Commission
Ml/d	Megalitres per day. A measure of discharge which is the rate of flow of water measured as a volume (megalitre) per unit time (day).
Murray REP2	Murray Regional Environment Plan No. 2. A planning instrument, gazetted in 1994, which applies to riverine lands of the Murray River and its effluents. It requires development consent from council for the construction or alteration of flood control works. It also places controls on the clearing of native vegetation and the management of wetlands.
NPWS	NSW National Parks and Wildlife Service

River Management Plan	A development control plan, plan of management, study, strategy, guideline or the like, that has undergone a public participation process, is consistent with the aims, objectives and principles of Murray REP2 and is endorsed by the MDBC.
Stage IV area	The downstream part of the floodplain of the Central Murray River and its effluents (principally the lower Edward and Wakool Rivers). It is defined in detail in Section 1.1 of the strategy.
Threatened Species	Species of plants and animals that are listed on the schedules of the *Threatened Species (Conservation) Act (1995).*
Water Act	Part 8 of the *Water Act (1912)* places controls on the construction of private earthworks that can affect the distribution of floodwaters on designated floodplains. Such works are identified as "controlled works" under the Act and require approval from the DLWC.
Wetlands	Depressions that are flooded or waterlogged often enough to support aquatic and semi-aquatic plants and animals.

APPENDICES

TEST FOR SIGNIFICANT EFFECT ON THREATENED FLORA SPECIES, POPULATIONS AND COMMUNITIES UNDER *THE THREATENED SPECIES CONSERVATION ACT (1995):*

THREATENED PLANTS ASSESSED

Callitriche cyclocarpa
Lepidium monoplocoides
Maireana cheelii
Solanum karsense
Stipa metatoris
Stipa wakoolica

Species: *Callitriche cyclocarpa*

Status: Vulnerable

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

This species is aquatic or semi-aquatic and was locally abundant in floodwaters between Lakes Talpile and Poomah in the Poon Boon Lakes system in 1974 (Margules *et al.* 1990). All existing functional aquatic ecosystems within the Stage IV area are contained within the floodway area as defined in the strategy in which flood control works will only be permitted if supported by a detailed assessment of impact. The strategy will therefore ensure that these ecosystems continue to be exposed to periodic flooding and will enable their productive capacity to be maintained. As a result, if a viable local population of this species is present in the Stage IV area, implementation of the strategy would not be expected to disrupt its life cycle. This population would not therefore be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by *Callitriche cyclocarpa*. Existing habitat that is currently exposed to a flooding regime will be wholly contained within the floodway area as defined in the strategy.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of *Callitriche cyclocarpa* in the Stage IV area. ***"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"***

The habitat of this species is poorly conserved within the Riverina Bioregion, as defined by ANCA (1995), where less than 1% of the region is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productive capacity of aquatic ecosystems in the study area to be maintained by ensuring continued exposure to a flooding regime. As a result, the strategy is not recognised as a threatening process to this species.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

Callitriche cyclocarpa has been recorded infrequently at scattered localities in Victoria and south-west NSW. The species was recorded near the Stage IV area in 1974, when it was locally abundant in floodwaters between Lakes Talpile and Poomah in the Poon Boon Lakes system. Most other records are pre-1920 (Margules *et al.* 1990). It may be near the limit of its known distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of *Callitriche cyclocarpa*.

Species: *Lepidium monoplocoides*

Status: Vulnerable

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

This species is an annual (or possibly perennial) forb which grows up to 20 centimetres high (Cunningham *et al.* 1984). It occurs on heavy soils subject to flooding and lighter soils above flood level (Margules *et al.* 1990).

Implementation of the strategy is not likely to disrupt the life cycle of any viable local population of *Lepidium monoplocoides* that may be present. The strategy will enable a continuation of the flood regime to areas currently exposed to periodic flooding. Consequently, the ecological benefits derived from flooding in this habitat will not be modified. Any viable local population that may be present would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by *Lepidium monoplocoides*.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of *Lepidium monoplocoides* in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

The habitat of this species is poorly conserved within the Riverina Bioregion, as defined by ANCA (1995), where less than 1% of the region is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will ensure continued exposure of functional floodplain areas to a flooding regime. The ecological benefits of flooding to these areas will therefore be maintained. As a result, the strategy is not recognised as a threatening process to this species.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The species was once widespread in semi-arid regions but is now known only in scattered locations (Margules *et al.* 1990). It has recently been recorded near Lake Urana about 200 kilometres east of the Stage IV area (NPWS pers. comm.). The Stage IV area is probably near the limit of its known distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of *Lepidium monoplocoides*.

Species: *Maireana cheelii*

Status: Vulnerable

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

This species is a small perennial forb, which grows up to 20 centimetres high and is found mainly on grey clay soils (Cunningham *et al.* 1984). It occurs in shallow depressions, at the foot of slopes, and in low areas subject to flooding (NPWS pers. comm.).

Implementation of the strategy is unlikely to disrupt the life cycle of any local viable population of *Maireana cheelii* that may be present on the floodplain of the Stage IV area. The strategy will enable a continuation of the flood regime to areas currently exposed to periodic flooding. Consequently, the ecological benefits derived from flooding in this habitat will not be reduced. Any viable local population that may be present would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population which may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy would not be likely to modify or remove any habitat of *Maireana cheelii*.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of *Maireana cheelii* in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

The habitat of this species is poorly conserved within the Riverina Bioregion, as defined by ANCA (1995), where less than 1% of the region is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable existing ecological benefits derived from flooding on the floodplain to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process to this species.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The species is restricted to the riverine plain from Hay south to Bendigo (Margules *et al.* 1990). Its predicted distribution based on climatic data (NPWS 1995) indicates that, in the Stage IV area, it may be near the western limit of its distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of *Maireana cheelii*.

Species: *Solanum karsense*

Status: Vulnerable

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

This species is a perennial forb which grows up to 25 centimetres high (Cunningham *et al.* 1984). The habitat of this species includes floodplain areas, flooded depressions and lakebeds (Scott 1992).

Under the strategy, existing habitats currently exposed to recurrent flooding will continue to be flooded. Consequently, the ecological benefits derived from flooding in these habitats will not be reduced. Implementation of the strategy would not be expected to disrupt the life cycle of any viable local population of *Solanum karsense* which may be present in the Stage IV area. This population would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by *Solanum karsense*.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of *Solanum karsense* in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

The habitat of this species is poorly conserved within the Riverina Bioregion, as defined by ANCA (1995), where less than 1% of the region is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the ecological benefits of flooding to the habitat of *Solanum karsense* to be maintained or enhanced. As a result, the strategy is not recognised as a threatening process to this species.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

This species occurs mainly in the south - west of NSW, extending up the Darling River to about Wilcannia (Cunningham *et al.* 1984). It has been recorded in the town of Balranald (NPWS 1995). Its predicted distribution based on climatic data (NPWS 1995) indicates that, in the Stage IV area, it may be near the southern limit of its distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of *Solanum karsense*.

Species: *Stipa metatoris*

Status: Vulnerable

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

This species is a grass that grows on sandy rises above normal flood levels (Margules *et al.* 1990). The species is also known to occur in flat, open mallee country. It is not considered to be flood-dependent. Consequently, implementation of the strategy would not be expected to disrupt the life cycle of any local viable population of *Stipa metatoris* in the Stage IV area. Such a population would , therefore, not be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by *Stipa metatoris*.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of *Stipa metatoris* in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

The habitat of this species is poorly conserved within the Riverina Bioregion, as defined by ANCA (1995), where less than 1% of the region is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will not affect the environment of *Stipa metatoris* and, therefore, is not recognised as a threatening process to this species.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

This species has been recorded in the Stage IV area at Stoney Crossing (1947) and Kyalite State Forest (1980, 1981, 1985) (Margules *et al.* 1990). Other records of this species are from elsewhere on the central Murray floodplain and in central NSW. Its predicted distribution based on climatic data (NPWS 1995) indicates that, in the Stage IV area, it may be near the southern limit of its distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of *Stipa metatoris*.

Species: *Stipa wakoolica*

Status: Endangered

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

This species is a grass which is known to occur on grey clay-loam soils on the Murray floodplain.

Implementation of the strategy will maintain a flood regime to any existing habitat currently exposed to recurrent flooding. Consequently, the ecological benefits derived from flooding in this habitat will not be reduced. Implementation of the strategy would not, therefore, be expected to disrupt the life cycle of any viable local population of *Stipa wakoolica* which may be present in the Stage IV area. Such a population would not be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by *Stipa wakoolica*.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of *Stipa wakoolica* in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

The habitat of this species is poorly conserved within the Riverina Bioregion, as defined by ANCA (1995), where less than 1% of the region is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the ecological benefits of flooding to the habitat of *Stipa wakoolica* to be maintained or enhanced. As a result, the strategy is not recognised as a threatening process to this species.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

This species has been recorded through the central Murray floodplain. Its predicted distribution based on climatic data (NPWS 1995) indicates that, in the Stage IV area, it may be near the southern limit of its distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of *Stipa wakoolica*.

NATIVE FAUNA OBSERVED IN STUDY AREA

Frogs

Peron's Tree Frog	*Litoria peronii*
Plains Froglet	*Crinia parinsignifera*
Common Eastern Froglet	*Crinia signifera*
Eastern Banjo Frog	*Limnodynastes dumerilii*
Long-thumbed Frog	*Limnodynastes fletcheri*
Spotted Grass Frog	*Limnodynastes tasmaniensis*
Brown Toadlet	*Pseudophryne bibronii*

Birds

Chestnut Teal	*Anas castanea*
Australasian Shoveller	*Anas rhynchotis*
Pacific Black Duck	*Anas superciliosa*
Hardhead	*Aythya australis*
Maned Duck	*Chenonetta jubata*
Plumed Tree Duck	*Dendrocygna eytoni*
Black Swan	*Cygnus atratus*
Pink-eared Duck	*Malacorhynchus membranaceus*
Australian Shelduck	*Tudorna tadomoides*
Grey Teal	*Anas gibberifrons*
Freckled Duck	*Stictonetta naevosa*
Musk Duck	*Biziura lobata*
Red-kneed Dotterel	*Erythogonys cinctus*
Greenshank	*Tringa nebularia*
Marsh Sandpiper	*Tringa stagnatilis*
Blue-billed Duck	*Oxyura australis*
Red-capped Plover	*Charadrius ruficapillus*
Black-fronted Plover	*Elseyornis melanops*
Masked Lapwing	*Vanellus miles*
Whiskered Tern	*Chlidonias hybridus*
Silver Gull	*Larus novaehollandiae*
Caspian Tern	*Sterna caspia*
Gull-billed Tern	*Gelochelidon nilotica*
Black-winged Stilt	*Himatopus himantopus*
Banded Stilt	*Cladorhynchus leucocephalus*
Australian Snipe	*Gallinago hardwickii*
Sharp-tailed Sandpiper	*Erolia acuminata*
Red-necked Stint	*Erolia ruficollis*
Australian Pratincole	*Stiltia isabella*
Red-necked Avocet	*Recurvirostra novaehollandiae*
Great Egret	*Ardea allon*
Cattle Egret	*Ardeola ibis*
Pacific Heron	*Ardea pacifica*
Large Egret	*Egretta alba*

Plumed Egret	*Egretta intermedia*
White-faced Heron	*Egretta novaehollandiae*
Rufous Night Heron	*Nycticorax caledonicus*
Little Bittern	*Ixobrychus minutus*
Yellow-billed Spoonbill	*Platalea flavipes*
Royal Spoonbill	*Platalea regia*
Glossy Ibis	*Plegadis falcinellus*
Australian White Ibis	*Threskiornis molucca*
Sacred Ibis	*Threskiornis aethiopica*
Straw-necked Ibis	*Threskiornis spinicollis*
Little Egret	*Egretta garzetta*
Common Bronzewing	*Phaps chalcoptera*
Banded Rail	*Rallus philippensis*
Spotted Crake	*Porzana fluminea*
Spotless Crake	*Porzana tabuensis*
Eurasian Coot	*Fulica atra*
Dusky Moorhen	*Gallinulla tenebrosa*
Bustard	*Ardeotis australis*
Masked Plover	*Vanellus miles novaehollandiae*
Banded Plover	*Vanellus tricolor*
Red-capped Dotterel	*Charadrius ruficapillus*
Black-fronted Dotterel	*Charadrius melanops*
Black-tailed Native Hen	*Gallinulla ventralis*
Purple Swamphen	*Porphyrio porphyrio*
Darter	*Anhinga melanogaster*
Australian Pelican	*Pelecanus conspicillatus*
Great Cormorant	*Phalacrocorax carbo*
Little Pied Cormorant	*Phalacrocorax melanoleucas*
Little Black Cormorant	*Phalacrocorax sulcirostris*
Pied Cormorant	*Phalacrocorax varius*
Great Crested Grebe	*Podiceps cristatus*
Little Grebe	*Podiceps ruficollis*
Hoary-headed Grebe	*Poliocephalus poliocephalus*
Sacred Kingfisher	*Todiramphus sanctus*
Azure Kingfisher	*Ceyx azureus*
Forest Kingfisher	*Halcyon macleayii*
Red-backed Kingfisher	*Halcyon pyrrhopygia*
Sacred Kingfisher	*Halcyon sancta*
Laughing Kookaburra	*Dacelo gigas*
Pied Butcherbird	*Cracticus nigrogularis*
Australian Magpie	*Gymnorhina tibicen*
White-winged Chough	*Corocrax melanorhamphos*
Australian Magpie Lark	*Grallina cyanoleuca*
Willie Wagtail	*Rhipidura leucophys*
Fairy Martin	*Hylochelidon ariel*
Tree Martin	*Hylochelidon nigricans*
Welcome Swallow	*Hirundo neoxera*
White-backed Swallow	*Cheromoeca leucosternum*
Spine-tailed Swift	*Hirundapus caudacutus*

Fork-tailed Swift	*Apus pacificus*
Masked Wood Swallow	*Artamus personatus*
White-breasted Wood Swallow	*Artamus leucorhynchus*
Ground Cuckoo-shrike	*Coracina maxima*
Superb Fairy-Wren	*Malurus cyaneus*
Rufous Whistler	*Pachycephala rufiventris*
Red-capped Robin	*Petroica goodenovii*
Flame Robin	*Petroica phoenicia*
Scarlet Robin	*Petroica multicolor*
Hooded Robin	*Petroica cucullata*
Southern Scrub Robin	*Drymodes brunneopygia*
Eastern Shrike-tit	*Falcunculus frontatus*
Golden Whistler	*Pachycephala pectoralis*
Grey Shrike Thush	*Colluricincla harmonica*
Crested Bellbird	*Oreoica gutturalis*
Restless Flycatcher	*Myiagra inquieta*
Galah	*Cacatua roseicapilla*
Mallee Ringneck	*Banardius zonarius barnardii*
Musk Lorikeet	*Glossopsitta concinna*
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*
Little Lorikeet	*Glossopsitta pusilla*
Yellow Rosella	*Platycercus elegans flaveoulus*
Red-rumped Parrot	*Psephotus haematonotus*
Blue Bonnet	*Northiella haematogaster*
Blue-winged Parrot	*Neophema chrysostoma*
Eastern Rosella	*Platycercus eximius*
Cockatiel	*Nymphicus hollandicus*
Budgerigar	*Melopsittacus undulatus*
Sulphur-crested Cockatoo	*Cacatua galerita*
Little Corella	*Cacatua sanguinea*
Regent Parrot	*Polytelis anthopeplus*
Pallid Cuckoo	*Cuculus pallidus*
Fan-tailed Cuckoo	*Cuculus pyrrhophanus*
Horsfield's Bronze Cuckoo	*Chrysococcyx basalis*
Crested Pigeon	*Ocyphaps lophotes*
Peaceful Dove	*Geopelia triata*
Diamond Dove	*Geopelia cuneata*
Rainbow Bee-Eater	*Merops ornatus*
Dollar Bird	*Eurystomus orientalis*
Chestnut Quail-thrush	*Cinclosoma castanotum*
Chestnut-crowned Babbler	*Pomatostomus nificeps*
Grey-crowned Babbler	*Pomatostomus temporalis*
White-browed Babbler	*Pomatostomus superciliosus*
Clamorous Reed Warbler	*Acrocephalus stentoreus*
Emu	*Dromaius novchollandiae*
Australian Raven	*Corvus coronoides*
Zebra Finch	*Poephila guttata*
Yellow-rumped Pardalote	*Pardalotus xanthopygus*
Painted Honeyeater	*Grantiella picta*

Blue-faced Honeyeater	*Entomyzon cyanotis*
Red Wattlebird	*Anthochaera carunculata*
White-plumed Honeyeater	*Lichenostomus penicillatus*
Noisy Miner	*Manorina melanocephala*
Little Friarbird	*Philemon citreogularis*
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*
White-winged Wren	*Malurus leucopterus*
Grey Fantail	*Rhipidura fuliginosa*
Jacky Winter	*Microeca lencophaea*
Red-capped Robin	*Petroica goodenovii*
Black-faced Cuckoo Strike	*Cornacina novaehollandiae*
White-winged Triller	*Lalage sueurii*
Richards Pipit	*Anthus novaeseelandiae*
Tree Martin	*Cecropis nigricans*
Black-shouldered Kite	*Elanus notatus*
Letter-winged Kite	*Elanus scriptus*
Whistling Kite	*Haliaster sphenurus*
Australian Goshawk	*Accipiter fasciatus*
Collared Sparrowhawk	*Accipiter cirhocephalus*
Grey Goshawk	*Accipiter novaehollandiae*
Australian Hobby	*Falco longipennis*
Australian Kestrel	*Falco cenchroides*
Black Falcon	*Falco subniger*
Peregrine Falcon	*Falco peregrinus*
Brown Falcon	*Falco benigora*
White-breasted Sea Eagle	*Haliaeetus leucogaster*
Wedge-tailed Eagle	*Aquila audax*
Little Eagle	*Hieraaetus morphnoides*
Spotted Harrier	*Circus assimilus*
Whistling Kite	*Haliastur sphenurus*
Swamp Harrier	*Circus approximans*
Boobook Owl	*Ninox novaeseelandiae*
Barking Owl	*Ninox connivens*
Barn Owl	*Tyto alba*
Tawny Frogmouth	*Podargus strigoides*
Owlet Nightjar	*Aegotheles cristatus*
Spotted Nightjar	*Eurostopodos guttatus*
Stubble Quail	*Coturnix pectoralis*
Brown Quail	*Coturnix australis*
Painted Button-Quail	*Turnix varia*
Little Button-Quail	*Turnix velox*
Little Crow	*Corvus bennettii*

Mammals

Western Broad-nosed Bat	*Nycticeius balstoni*
Echidna	*Tachyglossus aculeatus*
Western Grey Kangaroo	*Macropus fuliginosus*
Red Kangaroo	*Macropus nifus*
Water Rat	*Hydromys chrysogaster*
Sugar Glider	*Petaurus breviceps*
Common Brush-tailed Possum	*Trichosurus vulpecula*

Reptiles

Bearded Dragon	*Pogona barbata*
Murray Turtle	*Emydura macquarii*
Marbled Gecko	*Christinus marmoratus*
Eastern Long-necked Turtle	*Chelodina longicollis*
Eastern Tiger Snake	*Notechis scutatus*
Eastern Brown Snake	*Pseudonaja textilis*
Red-bellied Black Snake	*Pseudechis porphyriacus*
Gould's Goanna	*Varanus gouldii*
Lace Monitor	*Varanus varius*

Sources: Atkins (1994), National Parks and Wildlife Service (1996), Mid - Murray Field Naturalists Club (pers. comm.)

Fish

Recorded in the study area:

Golden Perch	*Macquaria ambigua*
Bony Herring	*Nematalosa erebi*
Australian Smelt	*Retropinna semoni*
Lake's Carp Gudgeon	*Hypseleotris sp1 (undescribed)*

Likely to occur in the study area:

Murray Cod	*Macullochella peelii peelii*
Trout Cod (endangered)	*Macullochella macquariensis*
Silver Perch (potentially threatened)	*Bidyanus bidyanus*
Western Carp - Gudgeon	*Hypseleotris klunzingeri*
Flat - Headed Gudgeon	*Philipnodon grandiceps*
River Blackfish	*Gadopsis marmoratus*
Murray River Galaxias	*Galaxias rostratus*
Lampreys	*Mordacia spp.*

Source: NSW Fisheries

TEST FOR SIGNIFICANT EFFECT ON THREATENED FAUNA SPECIES, POPULATIONS AND COMMUNITIES UNDER *THE THREATENED SPECIES CONSERVATION ACT (1995):*

THREATENED FAUNA ASSESSED

Australasian Bittern	*Botaurus poiciloptilus*
Black-breasted Buzzard	*Hamirostra melanosternon*
Black-tailed Godwit	*Limosa limosa*
Blue-billed Duck	*Oxyura australis*
Brolga	*Grus rubicundus*
Bush thick-knee	*Burhinus magnirostris*
Freckled Duck	*Stictonetta naevosa*
Gilbert's Whistler	*Pachycephala inornata*
Great Knot	*Calidris tenuirostris*
Greater Long-eared Bat	*Nyctophilus timeriensis*
Green and Golden Bell Frog	*Litoria raniformis*
Grey Falcon	*Falco hypoleucos*
Koala	*Phascolarctos cinereus*
Little Pied Bat	*Chalinolobus picatus*
Magpie Goose	*Anseranas semipalmata*
Masked Owl	*Tyto novaehollandiae*
Painted Honeyeater	*Grantiella picta*
Painted Snipe	*Rostratula benghalensis*
Pied Honeyeater	*Certhionyx variegatus*
Pink Cockatoo	*Cacatua leadbeateri*
Red-tailed Black Cockatoo	*Calyptorhynchus magnificus*
Regent Parrot	*Polytelis anthopeplus*
Spotted-tailed Quoll	*Dasyurus maculatus*
Square-tailed Kite	*Lophoictinia isura*
Superb Parrot	*Polytelis swainsonii*
Swift Parrot	*Lathamus discolor*

Species: Australasian Bittern *Botaurus poicilotilus*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

This species most frequently inhabits dense vegetation, including reed beds, sedges, rushes, Cumbungi and occasionally Lignum, surrounding wetlands (Marchant and Higgins 1990 cited in NPWS 1995). If present in the Stage IV area, this species would utilise well-vegetated wetlands as feeding and breeding sites.

All existing functional habitat of this type is contained within the floodway area, where flood control works will only be permitted if supported by a detailed assesment of impact. The strategy will, therefore, ensure that these ecosystems continue to be exposed to periodic flooding and will enable their productive capacity to be maintained. Consequently, implementation of the strategy is not expected to disrupt the life cycle of any viable, local population of Australasian Bittern that may occur. This population would not therefore be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Australasian Bittern.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Australasian Bittern in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

The habitat of this species is poorly conserved within the Riverina Bioregion, as defined by ANCA (1995), where less than 1% of the region is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will not affect the habitat of this species and therefore, is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Australasian Bittern is not at the limit of its known distribution. The species is predominantly located across south-eastern and south-western mainland Australia, Tasmania and New Zealand (Marchant and Higgins 1990 cited in NPWS 1995).

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Australasian Bittern.

Species: Black-breasted Buzzard *Hamirostra melanosternon*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Black-breasted Buzzard prefers tree-lined watercourses, ephemeral lakes and the open woodlands of associated floodplains as habitat (Marchant and Higgins 1990 cited in NPWS 1995). Nests are located in tall mature, dead or partially dead eucalypts often near a wetland or watercourse. Nest sites are traditional and may be used from year to year (Reader's Digest 1986 in NPWS 1995). The species is a generalist feeder taking reptiles, mammals, birds, amphibians and large insects.

Within the Stage IV area, flooding would generate benefits for this species by enhancing biological productivity in its habitats. Implementation of the strategy will sustain these benefits since flooding regimes to watercourses, riverine woodlands and wetlands that are currently exposed to periodic flooding will be maintained. This will sustain feeding habitat and will not affect the suitability of any existing nest sites (which are located near water). Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Black-breasted Buzzard. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Black-breasted Buzzard. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain and 80 hectares of wetlands may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Black-breasted Buzzard in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in the Riverina Bioregion, as defined by ANCA (1995), where less than one per cent of land is contained within conservation reserves. Potential habitat for the Black-breasted Buzzard may be represented in Yanga Nature Reserve (1772 hectares) near Balranald. This reserve consists mainly of Black Box woodland (Scott 1992).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Black-breasted Buzzard is distributed mainly through the northern interior, along adjacent coasts, and in the semi-arid and arid central regions of Australia (Readers Digest 1986 cited in NPWS 1995). The Stage IV area is not at the limit of known distribution for this species.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Black-breasted Buzzard.

Species: Black-tailed Godwit *Limosa limosa*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Black-tailed Godwit is a migratory wading bird that breeds in the Palearctic (Mongolia and Siberia) and visits Australia during spring and summer (Kingsford 1991 cited in NPWS 1995). It is primarily found on the coast but uses mudflats and the shallow portions of large muddy lakes in inland Australia. Its diet includes invertebrates, tadpoles and some plant material.

Implementation of the strategy is not expected to disrupt the life cycle of any viable local population of this species that may occur in the Stage IV area. The strategy will not modify the hydrological regime to existing habitat since all large lakes currently exposed to periodic flooding will be included within the floodway area. As a result, the productive capacity of these ecosystems will be maintained and feeding habitat will not be affected. Any existing population would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Black-tailed Godwit.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Black-tailed Godwit in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is generally poorly conserved within the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will not affect the habitat of this species and therefore, is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Black-tailed Godwit is not at the limit of its known distribution. Field atlas records show that the species is distributed through south-west NSW to the South Australian coast (Blakers *et al.* 1984).

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Black-tailed Godwit.

Species: Blue-billed Duck *Oxyura australis*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Blue-billed Duck is an almost wholly aquatic species that uses well-vegetated wetlands for breeding sites. Nests are constructed (in inland regions) in dense Cumbungi or sometimes Lignum, sedges, Spike-rush, Canegrass or Nitre-bush (Serventy 1985 cited in NPWS 1995). The Blue-billed Duck uses large, open wetlands during non-breeding periods. It feeds mainly on aquatic insects and plants.

Implementation of the strategy is not expected to disrupt the life cycle of any viable local population of this species that may occur in the Stage IV area. The strategy will not modify the hydrological regime to existing habitat since all aquatic ecosystems currently exposed to periodic flooding will be included within the floodway area. As a result, the productive capacity of these ecosystems will be maintained and feeding habitat will not be affected. Any existing population would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Blue-billed Duck. The potential restoration of a flooding regime to an additional 80 hectares of wetlands may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Blue-billed Duck in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

The habitat of this species is poorly conserved within the Riverina Bioregion as defined by ANCA (1995), where less than one per cent of the region is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will not affect the habitat of this species and therefore, is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Blue-billed Duck is not at the limit of its known distribution. It has been recorded throughout the Murray-Darling Basin (Blakers *et al.* 1984).

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Blue-billed Duck.

Species: Brolga *Grus rubicundus*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Brolga occurs on extensive open wetlands, including shallow swamps, their margins and floodplains. It also occurs on grasslands, paddocks, ploughed fields, irrigated pastures, stubble crops and salt flats (Pizzey 1980, Serventy 1985 cited in NPWS 1995). Roosting takes place beside swamps, waterholes and lakes. Brolgas are stimulated to breed by flooding (Briggs 1990 cited in NPWS 1995).

Implementation of the strategy is not expected to disrupt the life cycle of any viable local populations of this species since a flooding regime will be maintained to all existing functional wetlands and floodplain areas. This will facilitate the maintenance of biological productivity in these ecosystems. The strategy would not, therefore, place any local viable populations at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Brolga.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Brolga in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

Based on distributions shown in NPWS (1995), the Stage IV area is not at the limit of known distribution for the Brolga.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Brolga.

Species: Bush Thick-knee *Burhinus magnirostris*

Status: Threatened

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Bush Thick-knee is a ground-dwelling bird that favours riverine woodlands as habitat in inland Australia. It makes nests in bare ground and feeds at night on the ground or by wading (Pizzey 1980 cited in NPWS 1995). Its diet includes insects, aquatic invertebrates, small vertebrates and some plant material.

Implementation of the strategy will maintain flooding regimes to existing riverine woodlands and aquatic ecosystems that are currently exposed to recurrent flooding. Consequently, the ecological benefits of flooding to these habitats will be maintained. The strategy is not likely to disrupt the life cycle of any local viable populations of the Bush Thick-knee. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Bush Thick-knee. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain and 80 hectares of wetlands may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Bush Thick-knee in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Bush thick-knee has been recorded from widely distributed localities in inland NSW (NPWS 1995). The Stage IV area is not at the limit of known distribution for this species.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Bush Thick-knee.

Species: Freckled Duck *Stictonetta naevosa*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Freckled Duck uses a variety of plankton-rich wetland types as habitat. It feeds at wetland edges or in shallow productive waters. Nesting in NSW mainly occurs in swamps characterised by growths of Lignum that hold water for five or more months (Frith 1977 cited in NPWS 1995). Breeding is stimulated by flooding.

Implementation of the strategy will maintain flooding regimes to all existing wetlands that are currently exposed to recurrent flooding. This will enable the productive capacity of these ecosystems to be maintained. It will not affect breeding stimuli and conditions for this species. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Freckled Duck. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Freckled Duck. The potential restoration of a flooding regime to an additional 80 hectares of wetlands may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Freckled Duck in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Stage IV area is within the limits of known distribution for the Freckled Duck. The Murray-Darling Basin forms part of the eastern breeding stronghold of the Freckled Duck (Pizzey 1980 cited in NPWS 1995).

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Freckled Duck.

Species: Gilbert's Whistler *Pachycephala inornata*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The preferred habitat of Gilbert's Whistler appears to be mallee, although it also uses a range of other habitats (Pizzey 1980 cited in NPWS 1995). If present in the Stage IV area, it would be likely to inhabit riverine Black Box woodland, Lignum or partly cleared country. Gilbert's Whistler feeds on invertebrates, seeds and plant material. These are mainly taken from the ground.

Within the Stage IV area, flooding would generate benefits for this species by enhancing biological productivity in its habitats. Implementation of the strategy will sustain these benefits since flooding regimes to riverine woodlands and Lignum stands that are currently exposed to periodic flooding will be maintained. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of Gilbert's Whistler. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by Gilbert's Whistler. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of Gilbert's Whistler in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995). Potential habitat for Gilbert's Whistler is represented in Yanga Nature Reserve (1772 hectares) near Balranald. This reserve consists mostly of Black Box woodland (Scott 1992).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

Gilbert's Whistler is distributed throughout the southern mallee region and extends to to the north and east of the Stage IV area. The species is not at the limit of its known distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Gilbert's Whistler.

Species: Great Knot *Calidris tenuirostris*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Great Knot breeds in Siberia and migrates to Australia each October, returning in March. Within Australia, it occurs mostly in coastal habitats however a small proportion of birds use fresh and salt water lakes in inland areas (Pizzey 1980 in NPWS 1995). The birds forage in mud for invertebrates.

Implementation of the strategy will maintain flooding regimes to all existing wetlands that are currently exposed to recurrent flooding. This will enable the productive capacity of this habitat to be maintained. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Great Knot. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Great Knot.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Great Knot in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Great Knot is common in the northern coastal regions of Australia but is uncommon to rare farther south. Within inland NSW, the only recording of the species has been at the Tullakool Evaporation Ponds (NPWS 1995). This location is about 40 kilometres south - east of the Stage IV area. Consequently, the species would be near the limit of its known inland distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Great Knot.

Species: Greater Long-eared Bat *Nyctophilus timoriensis*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

Within the inland plains of the semi-arid zone, this species occurs in dry open woodlands and around River Red Gums that line watercourses and lakes (Richards 1983 cited in NPWS 1995). It forages for large moths and beetles over water.

Within the Stage IV area, flooding would generate benefits for this species by enhancing biological productivity in its habitats. Implementation of the strategy will sustain these benefits since flooding regimes to wetlands, watercourses and riverine woodlands that are currently exposed to periodic flooding will be maintained. These areas are included within the boundaries of the floodway. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Greater Long-eared Bat. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Greater Long-eared Bat. The potential restoration of a flooding regime to an area of 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Greater Long-eared Bat in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995). Potential habitat is represented in Yanga Nature Reserve (1772 hectares) near Balranald. This reserve consists mostly of Black Box woodland (Scott 1992).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Greater Long-eared Bat has a very extensive distribution, but is now recognised as a complex and is under taxonomic revision (Dickman *et al.* 1993 cited in NPWS 1995). The eastern subspecies is probably a distinct species with about half its range in the southern and eastern parts of inland NSW (NPWS 1995). The Stage IV area is within the limits of its known distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Greater Long-eared Bat.

Species: Green and Golden Bell Frog *Litoria raniformis*

Status: Threatened

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

This is a largely aquatic species found among vegetation within or at the edges of permanent water (including streams, wetlands and farm dams) (Robinson 1993 cited in NPWS 1995). It feeds mainly on invertebrates and other frogs.

Implementation of the strategy is not likely to disrupt the life cycle of any local viable population of the Green and Golden Bell Frog. Permanent wetlands and watercourses, potentially used by this species in the Stage IV area, are wholly within the boundaries of the floodway area where flood control works will only be permitted if supported by a detailed assessment of impact. The strategy will therefore enable a continued hydrological regime to this habitat. Any local viable population present would not be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Green and Golden Bell Frog.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Green and Golden Bell Frog in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

The habitat of this species is poorly conserved within the Riverina Bioregion, as defined by ANCA (1995), where less than 1% of the region is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will not affect the habitat of this species and therefore, is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Green and Golden Bell Frog is not at the limit of its known distribution. On mainland Australia, the species is distributed from the south - east slopes and plains of NSW through Victoria to south-eastern South Australia (Cogger 1994 cited in NPWS 1995).

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Green and Golden Bell Frog.

Species: Grey Falcon *Falco hypoleucos*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Grey Falcon inhabits a range of habitat types but requires large eucalypt trees near or overhanging water or a dry watercourse for nesting sites (NPWS 1995). Potential habitat in the Stage IV area would include timbered drainage lines and wetlands where the surface water attracts prey. It feeds mainly on birds, some small mammals and reptiles, and occasional insects and earthworms. Some pairs of these birds exhibit fidelity to a particular breeding territory (Marchant and Higgins 1993 in NPWS 1995).

Implementation of the strategy is not expected to disrupt the life cycle of any viable local population of this species that may be present. All existing watercourses, riverine woodland and wetlands that are currently exposed to periodic flooding will be contained within the floodway area where flood control works will onl;y be permitted following a detailed assessment of impact. As a result, the strategy will enable continued flooding of these habitats and consequently will enable their productive capacity to be maintained. It will help to sustain feeding and breeding habitat for this species. Any existing population would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Grey Falcon. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain and 80 hectares of wetlands may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Grey Falcon in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in the Riverina Bioregion, as defined by ANCA (1995), where less than one per cent of land is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Grey Falcon is widely distributed across tropical and temperate mainland Australia but is rarely seen (Marchant and Higgins 1993 cited in NPWS 1995). The Stage IV area is within the limit of known distribution for this species.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Grey Falcon.

Species: Koala *Phascolarctos cinereus*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Koala is restricted to open forest and woodland areas where there are acceptable food trees on higher nutrient status soils. River Red Gum is the principal food source of the Koala in the western Region of NSW (NPWS 1995.) The animal is also known to occasionally feed on the leaves of Black Box (Lee and Martin 1988).

Within the Stage IV area, flooding would generate benefits for this species by enhancing biological productivity in its habitat. Implementation of the strategy will sustain this benefit since flooding regimes to riverine woodlands and forests that are currently exposed to periodic flooding will be maintained. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of Koala. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Koala. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Koala in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

There is evidence of Koalas in Mallee Cliffs National Park about 80 kilometres from the Stage IV area (NPWS 1995). Generally, habitat is poorly conserved within the Riverina Bioregion as defined by ANCA (1995).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

There have been isolated recordings of Koalas to the west of the Stage IV area in inland NSW (NPWS 1995). The Stage IV area is within the known limits of its distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Koala.

Species: Little Pied Bat *Chalinobolus picatus*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

Based on habitat requirements in NPWS (1995), the Little Pied Bat would be likely to inhabit riverine woodlands if it is present in the Stage IV area. The species is known to use tree hollows as roosting sites. It eats insects and requires access to free – standing water.

Periodic flooding generates benefits for this species by enhancing biological productivity in its habitats. Implementation of the strategy will sustain these benefits since flooding regimes to riverine woodlands and aquatic habitats that are currently exposed to periodic flooding will be maintained. These areas are included within the boundaries of the floodway. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Little Pied Bat. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Little Pied Bat. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Little Pied Bat in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995). Habitat may be represented in Yanga Nature Reserve (1772 hectares) near Balranald. This reserve consists mostly of Black Box woodland (Scott 1992).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Little Pied Bat is distributed through arid and semi-arid zones of eastern Australia. Based on its distribution map in NPWS (1995), the species may be near the eastern limit of its known distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Little Pied Bat.

Species: Magpie Goose *Anseranas semipalmata*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Magpie Goose inhabits wetlands, especially those with dense growths of rushes, and with permanent lagoons and grasslands nearby. It also uses floodplains during wet and dry periods (Pizzey 1980 cited in NPWS 1995). The species feeds by both filtering and grazing. Its diet includes aquatic and terrestrial plants and invertebrates. The Magpie Goose prefers to feed in open places including the shallow water at lagoon edges, in pastures, rice fields and crops. The onset of breeding is strongly influenced by water level and the composition and structure of swamp vegetation (Harper 1990 in NPWS 1995).

Implementation of the strategy is not expected to disrupt the life cycle of any viable local populations of this species since a flooding regime will be maintained to all existing functional wetlands and floodplain areas. This will facilitate the maintenance of biological productivity in these ecosystems. The strategy is not expected to affect existing breeding stimuli or food availability for this species The strategy would not, therefore, place any local viable populations at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Magpie Goose.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Magpie Goose in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

Magpie Geese travel throughout Australia during the northern dry season (Reader's Digest 1986 cited in NPWS 1995). The species has largely disappeared from southern Australia however, and despite some increases in population during the 1980s, it remains rare in NSW. The Stage IV area is not at the limit of known distribution for the Magpie Goose.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Magpie Goose.

Species: Masked Owl *Tyto novaehollandiae*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Masked Owl inhabits forests, open woodlands, adjacent cleared country and timbered watercourses (Pizzey 1980 cited in NPWS 1995). Based on nesting preferences listed in NPWS (1995), the birds would nest in the hollow trunks of eucalypts 12 to 20 metres high, if present in the Stage IV area. The Masked Owl eats a variety of small terrestrial mammals, medium-sized birds and some insects.

Implementation of the strategy is not expected to disrupt the life cycle of any viable local population of this species that may be present. All existing watercourses and riverine woodland that are currently exposed to periodic flooding will be contained within the floodway area where flood control works will only be permitted following a detailed assessment of impact. As a result, the strategy will enable the productive capacity of these habitats to be maintained. Any existing population would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Masked Owl. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Masked Owl in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in the Riverina Bioregion, as defined by ANCA (1995), where less than one per cent of land is contained within conservation reserves. Potential habitat is represented in Yanga Nature Reserve (1772 hectares) near Balranald. This reserve consists mainly of Black Box woodland (Scott 1992).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Masked Owl is widespread across Australia, except in the arid interior (Pizzey 1980 cited in NPWS 1995). It is infrequently sighted in inland areas. The distribution map in NPWS (1995) indicates that the downstream end of the Stage IV area may be near the inland limit of the Masked Owl in south - west NSW.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Masked Owl.

Species: Painted Honeyeater *Grantiella picta*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Painted Honeyeater inhabits a range of open forests and woodlands. It feeds primarily on mistletoe berries, but occasionally eats mistletoe nectar, eucalypt flowers and insects (Barker and Vestjens undated cited in NPWS 1995). It can be found virtually anywhere that mistletoe occurs (NPWS 1995). If present in the Stage IV area, the Painted Honeyeater would be likely to inhabit riverine forests and woodlands.

Within the Stage IV area, flooding would generate benefits for this species by enhancing biological productivity in its habitats. Implementation of the strategy will sustain these benefits since flooding regimes to riverine forests and woodlands that are currently exposed to periodic flooding will be maintained. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Painted Honeyeater. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Painted Honeyeater. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Painted Honeyeater in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995). Potential habitat is represented in Yanga Nature Reserve (1772 hectares) near Balranald. This reserve consists mostly of Black Box woodland (Scott 1992).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Painted Honeyeater is not at the limit of its known distribution. It is distributed across inland eastern Australia (NPWS 1995).

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Painted Honeyeater.

Species: Painted Snipe *Rostratula benghalensis*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Painted Snipe inhabits the fringes of wetlands, generally where there is vegetative cover including samphire, grasses, low scrub, Lignum and open timber (Slater *et al.* 1986 cited in NPWS 1995). Nests are constructed above water level on small islands or hummocks surrounded by shallow water. The bird feeds in the mud at wetland edges on aquatic invertebrates, aquatic plants and seeds.

Implementation of the strategy is not likely to disrupt the life cycle of any local viable population of the Painted Snipe. Wetlands that are currently exposed to periodic flooding are wholly within the boundaries of the floodway area where flood control works will only be permitted if supported by a detailed assessment of impact. The strategy will therefore enable a continued hydrological regime to this habitat and will ensure that the ecological benefits of flooding are maintained. Any local viable population present would not be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Painted Snipe. The potential restoration of a flooding regime to an area of 80 hectares of wetlands may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Painted Snipe in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

The habitat of this species is poorly conserved within the Riverina Bioregion, as defined by ANCA (1995), where less than 1% of the region is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will not affect the habitat of this species and therefore, is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Painted Snipe is not at the limit of its known distribution. The species is distributed throughout eastern Australia to the Victorian and South Australian coasts (Blakers *et al.* 1984).

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Painted Snipe.

Species: Pied Honeyeater *Certhionyx variegatus*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Pied Honeyeater inhabits a range of habitat types including Mulga, mallee, spinifex and eucalypt woodlands, usually when shrubs are flowering (Pizzey 1980 cited in NPWS 1995). It is known to occur in the southern riverine woodlands of NSW. Its main food source is nectar from flowering shrubs (*Eremophila* spp., *Brachysema* spp. and *Grevillea* spp.) and mistletoe (NPWS 1995). The bird constructs a nest in the fork of a shrub or tree up to 5 metres high.

Within the Stage IV area, flooding would generate benefits for this species by enhancing biological productivity in its habitat. Implementation of the strategy will sustain these benefits since flooding regimes to riverine woodland that are currently exposed to periodic flooding will be maintained. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Pied Honeyeater. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Pied Honeyeater. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Pied Honeyeater in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995). Potential habitat is contained in Yanga Nature Reserve (1772 hectares) near Balranald. This reserve consists mostly of Black Box woodland (Scott 1992).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Pied Honeyeater is widespread throughout arid and semi-arid Australia but is nomadic and rarely seen (NPWS 1995). The species is not at the limit of its distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Pied Honeyeater.

Species: Pink Cockatoo *Cacatua leadbeateri*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Pink Cockatoo uses a variety of habitats in the inland, including woodlands and grasslands near tree-lined watercourses (Slater *et al.* 1986 cited in NPWS 1995). It requires access to fresh water and large, hollow limbs or holes in trees for nesting sites. The bird is known to occur in the southern riverine woodlands of NSW. If present in the Stage IV area, it would be likely to use suitable River Red Gum or Black Box trees as nesting sites. Diet includes seeds, nuts, fruits and roots, particularly of Cypress Pine and acacias, but also of eucalypts, *Bassia* and *Casuarina* species (Reader's Digest 1986 cited in NPWS 1995).

Implementation of the strategy will maintain flooding regimes to existing riverine woodlands and aquatic ecosystems that are currently exposed to recurrent flooding. Consequently, the ecological benefits of flooding to these habitats will be maintained. The strategy is not likely to disrupt the life cycle of any local viable populations of the Pink Cockatoo. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Pink Cockatoo. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Pink Cockatoo in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995). Potential habitat is contained in Yanga Nature Reserve (1772 hectares) near Balranald. This reserve consists mostly of Black Box woodland (Scott 1992).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Pink Cockatoo is not at the limit of its known distribution. The eastern race of this species is widespread throughout most of western NSW (NPWS 1995).

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Pink Cockatoo.

Species: Red-tailed Black Cockatoo *Calyptorhynchus magnificus*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Red-tailed Black Cockatoo occurs mainly in eucalypt woodlands along watercourses, but is also found in open forests and woodlands, as well as grasslands (Pizzey 1980 cited in NPWS 1995). Nests are constructed in large hollows of dead or mature River Red Gums. The birds feed on the ground along floodplains. They eat a variety of seeds and fruits and some bulbous roots and beetle larvae.

Implementation of the strategy will maintain flooding regimes to existing riverine woodlands and forests, as well as to floodplain areas that are currently exposed to recurrent flooding. This will enable the biological productivity of these ecosystems to be maintained. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Red-tailed Black Cockatoo. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Red-tailed Black Cockatoo. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Red-tailed Black Cockatoo in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in nature reserves in the Riverina Bioregion where less than one per cent of land is contained within conservation reserves (ANCA 1995). Potential habitat is contained in Yanga Nature Reserve (1772 hectares) near Balranald. This reserve consists mostly of Black Box woodland (Scott 1992).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The distribution of the Red-tailed Black Cockatoo in western NSW is closely associated with the Darling River and its tributaries (NPWS 1995). The Stage IV area may be near the south-eastern limit of known distribution for this species.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Red-tailed Black Cockatoo.

Species: Regent Parrot *Polytelis anthopeplus*

Status: Threatened

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The eastern race of the Regent Parrot broadly occurs in inland south - eastern Australia near river systems and lakes (Pizzey 1980 cited in NPWS 1995). The bird has a restricted habitat preference. It requires areas of River Red Gum or Black Box woodland (as nesting sites) adjacent to mallee woodland (where it feeds). Nests are constructed in hollows within tall, mature or dead eucalypts with a broad crown. Typically, the nests are within 60 metres of permanent water. There is a high fidelity of nesting sites and nests are usually located within close proximity of others (Priddel 1989 in NPWS 1995). The bird feeds on seed, berries, buds, shoots, blossoms and rarely, insects. Although feeding predominantly in mallee woodlands, it is known to forage on the ground in Black Box woodlands and to eat River Red Gum seed. Based on habitat requirements, the Regent Parrot is probably restricted (within the Stage IV area) to the area downstream of Kyalite.

Flooding would generate benefits for this species by enhancing biological productivity in its riverine woodland habitats. Implementation of the strategy will sustain these benefits since flooding regimes to riverine woodlands that are currently exposed to periodic flooding will be maintained. These areas are included within the boundaries of the floodway. Additionally, the strategy will enable a continued hydrological regime to existing permanent watercourses. As a result, it would not be expected to affect the suitability of existing nesting sites (which are located near water). Overall, the strategy is not likely to disrupt the life cycle of any local viable populations of the Regent Parrot. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population which may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Regent Parrot.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Regent Parrot in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Regent Parrots are known from Mallee Cliffs National Park (NPWS 1995) about 80 kilometres west of the Stage IV area. Generally however, habitat is poorly represented in conservation reserves in the Riverina Bioregion, where less than one per cent of land is contained within nature reserves (ANCA 1995).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The distribution of the Regent Parrot in inland NSW is restricted largely to areas along the Murray River downstream of the Murrumbidgee junction (NPWS 1995). The downstream end of the Stage IV area is near the eastern limit of its known distribution.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Regent Parrot.

Species: Spotted-tailed Quoll *Dasyurus maculatus*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Spotted Quoll inhabits sclerophyll forests, woodlands and rainforests. It is a marginal inhabitant of the arid zone. If present in south - western NSW, it probably occurs within River Red Gum forests (Dickman and Read 1992 in NPWS 1995). It is an opportunistic carnivore which feeds on birds, reptiles, small mammals and invertebrates. Nest sites within the Stage IV area would be in tree hollows or hollow logs.

Within the Stage IV area, flooding would generate benefits for this species by enhancing the biological productivity of its habitat. Implementation of the strategy will sustain this benefit since flooding regimes to riverine woodlands and forests that are currently exposed to periodic flooding will be maintained. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Spotted-tailed Quoll. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Spotted-tailed Quoll. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Spotted-tailed Quoll in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat is poorly conserved within the Riverina Bioregion as defined by ANCA (1995). Less than one per cent of land in the Bioregion is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

There have been isolated recordings of the Spotted-tailed Quoll at Hay (late 1970s) and Swan Hill (1992) (Dickman and Read 1992 cited in NPWS 1995). The Stage IV area is near the limit of known distribution for the species in inland NSW.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Spotted-tailed Quoll.

Species: Square-tailed Kite *Lophoictinia isura*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Square-tailed Kite uses a variety of habitats including open forests, woodlands, scrubs and heathlands. It is predominantly found in coastal and sub-coastal areas but was formerly regarded as an inland bird (Marchant and Higgins 1993 cited in NPWS 1995). Its most common habitat in inland NSW is riverine eucalypt woodlands and nearby chenopod and grass-covered plains. Nests are constructed in mature, living trees near an assured food supply and often within 100 metres of a watercourse. The same nest may be used for breeding year after year (Slater *et al.* 1986 in NPWS 1995). The bird favours the margins between open and timbered country for hunting. Its diet includes small birds, nestlings and eggs, as well as foliage insects. Small mammals and frogs are also taken (Marchant and Higgins 1993 cited in NPWS 1995).

Within the Stage IV area, flooding would generate benefits for this species by enhancing biological productivity in its habitat. Implementation of the strategy will sustain this benefit since flooding regimes to riverine woodlands that are currently exposed to periodic flooding will be maintained. Additionally, the strategy will enable a continuation of the hydrological regime to existing functional watercourses and would not affect the suitability of existing nest sites. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Square-tailed Kite. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Square-tailed Kite. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the expansion of suitable habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Square-tailed Kite in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in the Riverina Bioregion, as defined by ANCA (1995), where less than one per cent of land is contained within conservation reserves. Potential habitat for this species is represented in Yanga Nature Reserve (1772 hectares) near Balranald. This reserve consists almost entirely of Black Box woodland (Scott 1992).

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Square-tailed Kite is widely but sparsely distributed across much of Australia. The Stage IV area is within the limits of known distribution for this species.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Square-tailed Kite.

Species: Superb Parrot *Polytelis swainsonii*

Status: Vulnerable and Rare

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Superb Parrot is an inhabitant of the open woodlands and riverine forests in inland NSW (Slater *et al.* 1986 in NPWS 1995). The species appears to have two distinct breeding populations. These occur in the Murray-Riverina area and on the South-West Slopes. The bird has a restricted habitat preference in the Murray-Riverina area. It nests in the hollows of mature, healthy River Red Gum trees close to water and within 10 kilometres of Grey or Yellow Box woodland foraging sites (Webster 1988 in NPWS 1995). The birds show a high fidelity to breeding sites.

If present in the Stage IV area, this species would derive benefits from flooding. Flooding sustains the health and regeneration of River Red Gum trees that are used as nesting habitat. Implementation of the strategy would maintain these benefits since flooding regimes to riverine forests and woodlands that are currently exposed to periodic flooding will be maintained. Additionally, the strategy will enable a continuation of the hydrological regime to existing functional watercourses and would not affect the suitability of existing nest sites (which are located close to water). Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Superb Parrot. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,"

Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Superb Parrot.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Superb Parrot in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in the Riverina Bioregion, as defined by ANCA (1995), where less than one per cent of land is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

The Superb Parrot is rarely recorded south of the Murray River (Blakers *et al.* 1984). The Stage IV area is near the limit of known distribution for this species.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Superb Parrot.

Species: Swift Parrot *Lathamus discolor*

Status: Endangered

"(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,"

The Swift Parrot breeds in Tasmania and adjacent islands and migrates to south - eastern mainland Australia to feed during winter (Slater *et al.* 1986 in NPWS 1995). On the mainland, the birds occur in a wide variety of habitats. They are nomadic in response to the availability of blossom and other food sources. Principal foods are eucalypt nectar and pollen, as well as lerps. Banksia nectar, insects and their larvae, seeds, fruits, berries and some vegetative matter are also eaten (Pizzey 1980 in NPWS 1995).

If present in the Stage IV area, the Swift Parrot would be likely to use River Red Gum and Black Box woodlands as feeding habitat. Flooding would generate benefits for this species by enhancing biological productivity in this habitat. Implementation of the strategy would maintain these benefits since flooding regimes to riverine woodlands that are currently exposed to periodic flooding will be maintained. Consequently, the strategy is not likely to disrupt the life cycle of any local viable populations of the Swift Parrot. Such populations would not, therefore, be placed at risk of extinction.

"(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,"

For the reasons stated above, implementation of the strategy would not be expected to disrupt the life cycle of any endangered population that may be present.

"(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed," Implementation of the strategy is not likely to modify or remove any existing habitat that may be used by the Swift Parrot. The potential restoration of a flooding regime to an area of up to 2000 hectares of floodplain may facilitate the regeneration of suitable feeding habitat for this species.

"(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,"

Implementation of the strategy would not be expected to isolate any existing areas of known habitat from any currently interconnecting or proximate areas of habitat.

"(e) whether critical habitat will be affected,"

As yet, no critical habitat has been declared under the *Threatened Species Conservation Act (1995).* Part (e) can not be applied to the habitat of the Swift Parrot in the Stage IV area.

"(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,"

Habitat for this species is poorly represented in the Riverina Bioregion, as defined by ANCA (1995), where less than one per cent of land is contained within conservation reserves.

"(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,"

Implementation of the strategy will enable the productivity of habitat for this species to be maintained or enhanced. For this reason, the strategy is not recognised as a threatening process.

"(h) whether any threatened species, population or ecological community is at the limit of its known distribution."

Swift Parrots are found in suitable areas from South Australia to south - eastern Queensland. Within NSW they are mostly found in the south - east (Pizzey 1980 in NPWS 1995). The Stage IV area is near the inland limit of known distribution in southern NSW.

CONCLUSION:

Subject to further assessment of specific works applications, implementation of the strategy is not likely to significantly affect the environment of the threatened Swift Parrot.

Figures 8 to 18