A Management Plan for the Improvement of Urban Stormwater Quality for the Mildura Rural City Council.

Volume 2 - Background

November 2001

Research Planning Design Group

ARCHAEOLOGICAL CONSULTING SERVICES

Lloyd Environmental Consultants

SINCLAIR KNIGHT MERZ

Mildura Rural City Council

A Management Plan for the Improvement of Urban Stormwater Quality for the Mildura Rural City Council

Volume II: Background

Final

November 2001

Funding Stakeholder Organisations:

Mildura Rural City Council

Sunraysia Rural Water Authority

First Mildura Irrigation Trust

Department of Natural Resources and Environment

Mallee Catchment Management Authority

Environment Protection Authority

Lower Murray Water

In-kind Stakeholder Contributors:

Goulburn-Murray Water

Murray Darling Basin Commission

SINCLAIR KNIGHT MERZ

Sinclair Knight Merz Pty Limited
ACN 001 024 095
ABN 37 001 024 095
590 Orrong Road
Armadale VIC 3143
PO Box 2500
Malvern VIC 3144
Australia
Telephone: +61 3 9248 3100
Facsimile: +61 3 9248 3364

Contents

Document History and Status

Issue	Rev.	Issued To	Qty	Date	Reviewed	Approved
Draft a	1	Reference Group & Project Working Group	15 & email	20/9/01	Reference Group & Project Working Group	David Sheehan
Final	2	Reference Group & Project Working Group	15 & email	4/10/01 (reissued 17/10/01)	Reference Group & Project Working Group	David Sheehan
Final	3	Ron Dudley	50	9/11/01		David Sheehan

Printed:	1 July, 2002
Last Saved:	9 November, 2001
File Name:	I:\WCMS\Wc01738\REP01_05.22\Final Stormwater Plan\RO1_ST_SWMP Volume 2_Final1.Doc
Project Manager:	David Sheehan
Name of Organisation:	Mildura Rural City Council
Name of Project:	Urban Stormwater Management Plan
Name of Document:	A Management Plan for the Improvement of Urban Stormwater Quality for the Mildura Rural City Council
Document Version:	Final
Project Number:	WC01738

1. Introduction

Sinclair Knight Merz was contracted by the Mildura Rural City Council (Council) to assist with the development of an Urban Stormwater Quality Management Plan (SWMP) which will guide the Council in improving environmental management and quality of stormwater runoff from urban areas throughout the municipality. This plan was conducted as part of a broader drainage strategy for the Sunraysia region that was aimed at developing a blueprint for urban development in the region up to the year 2050.

The Stormwater Management Plan has been developed in a number of stages as guided by the requirements of the Victorian Stormwater Action Program (VSAP) and involved close consultation with Council and other stakeholders. The outcomes from this process have been complied into a number of reports (Issues Papers 3, 5 and 7 in this series relate to the Sunraysia Drainage Strategy and not directly to the Stormwater Management Plan):

- **Issues Paper no. 1 – Background.** This report provided an overview of the urban stormwater and irrigation drainage system in the Sunraysia region
- **Issues Paper no. 2 – Threats and Values.** This report provided details of the values of the environments that receive urban stormwater runoff and the threats to those values from urban stormwater runoff. As part of the assessment process, the threats and values associated with irrigation drainage in the region were also assessed.
- **Issues Paper no. 4 – Risk Assessment.** This report described the risk assessment and prioritisation process necessary to determine the priority management issues that would become the focus of actions aimed at improving the quality of urban stormwater runoff.
- **Issues Paper no. 6 – Stormwater Management Actions.** This report summarised management actions aimed at addressing the priority issues identified in Issues Paper no. 4.

The contents of these reports formed the basis for stakeholder consultation at Project Working Group workshops. Based on the discussion at these workshops, the reports have been revised and complied into 2 separate volumes that form the final stormwater management plan in the format required by VSAP:

- **Volume I: Executive Summary** provides an overview of why and how the plan was developed and details management actions and recommendations that Council can use to improve stormwater management.
- **Volume II: Background** (this report) provides more detailed background and information that clearly describes the methodology followed and more detail on the assessment of threats, values and strategy development and includes all appendices. It represents a compilation of Issues Papers 1, 2, 4 and 6 fully revised to reflect the outcomes of stakeholder involvement at the Reference Group meetings and Project Working Group workshops.

1.1 Why develop a stormwater management plan?

When it rains water runs off streets, carparks, the roofs of houses and other surfaces into the nearest waterway or wetland. This runoff can enter waterways via a subsurface network of pipes or as surface runoff. Most urban areas have a system of

pipes with entry points to drain stormwater, however in outer urban and rural areas there may be no pipes infrastructure and stormwater is drained via open gutters.

Unlike sewage, 'stormwater' is not treated in anyway before it enters waterways. In urban areas, stormwater accumulates pollutants as it flows over hard surfaces. These pollutants include nutrients, sediments, litter, oils and grease and other toxicants and can negatively impact upon the water quality in urban waterways. Because stormwater is not treated prior to entering waterways, activities in the catchment have a direct influence on the quality of stormwater and hence the quality of water in our rivers, creeks, lakes and wetlands.

Stormwater runoff has been identified as a major contributor to degradation in many urban environments. As such, the State Government of Victoria through the Environment Protection Authority (EPA), Catchment Management Authorities and other agencies are supporting local Councils in the development of stormwater management plans for urban areas in their municipalities. The Victorian Stormwater Committee has been established to assist with the development of stormwater management plans, the objectives of which are to:

Identify actions to improve the environmental management of urban stormwater and protect the environmental values and beneficial uses of receiving environments

Stormwater management plans identify the values of receiving environments and the threats to those values from stormwater, prioritises the key management issues and recommend actions to address those issues.

2. The stormwater planning process

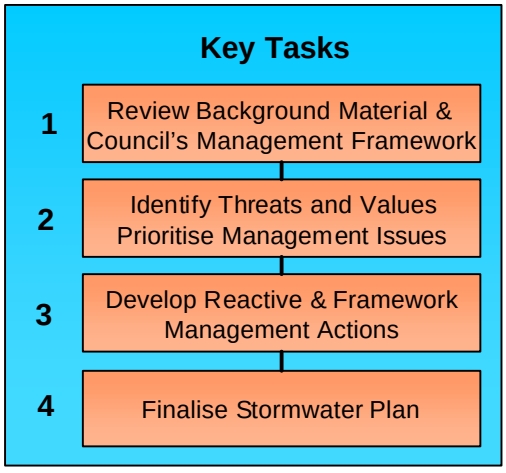
The methodology for developing stormwater management plans has been established by the Victorian Stormwater Committee in conjunction with the Environment Protection Authority (EPA), Melbourne Water, Catchment Management Authorities and the Department of Natural Resources and Environment (NRE) and are defined in the Best Practice Environmental Management Guidelines. These guidelines are being followed in the development of the SWMP for Mildura Rural City Council.

The key tasks followed in the development of this stormwater management plan consisted of:

1) The identification and review of background issues;
2) The review of local government management and operations as it relates to stormwater management;
3) The identification of values of environments receiving urban stormwater;
4) The identification of threats to receiving environments from stormwater inputs;
5) A risk assessment and prioritisation process to determine the priority stormwater management issues;
6) The development of reactive management strategies for managing stormwater that addressed the priority management issue;
7) The development of Council management actions that will lead to an improvement in the ability of the Mildura Rural City Council to better manage stormwater quality; and,
8) The provision of indicative costings, responsibilities and timelines for implementation of the strategies identified in the stormwater management plan.

These tasks are conducted in four stages as outlined in Figure 2.1. All stages, in the process involve stakeholder input with four workshops conducted to separately discuss each stage of the plan.

■ **Figure 2.1. The stormwater planning process**



The final SWMP is a document that Mildura Rural City Council can use to better manage urban stormwater quality and improve the health of the Murray River, wetlands and drainage basins. To be most effective, the plan must:

- Have Council-wide (Council and Officer) commitment to the plan and its implementation;
- Set priorities for the Council's management of urban stormwater;
- Include clearly stated strategic objectives;
- Incorporate a risk-based assessment of issues and threats;
- Include strategies with clear actions that address priority risks, together with measurable environmental outcomes wherever possible;
- Follow the principle of continuous improvement; and
- Encourage all stakeholders.

This report is **Volume II** of a *Management Plan for the Improvement of Urban Stormwater Quality for Mildura Rural City Council.* It provides the details of the process followed in the development of the stormwater management actions and background to support the overall stormwater management plan presented in **Volume I**. In particular, this report presents details of the assessment of the values of waterways and wetlands that receive urban stormwater runoff in the Mildura area, an assessment of the threats to those values from stormwater runoff and details of the risk assessment process used to prioritise the key stormwater management issues in the region. This report also provides a review of Council's management framework as it relates to stormwater and environmental management. The review examined Council's strategic documents, planning processes and day to day management activities to identify deficiencies that are impacting on Council's ability to successfully manage stormwater in the region.

Actions have then been developed to address the priority management issues and issues arising from the Council review. Details are provided of the process by which actions were identified and assessed. The final suite of recommended actions are those presented in **Volume I** of the stormwater management plan.

3. The Mildura Rural City Council area

The Mildura Rural City Council is the largest municipality in Victoria covering 22,330 sq km in the State's north west. This study focuses on the urban centres in the greater Mildura area that include Mildura (current population 25,000), Merbein (3,000), Irymple (2,000) and Red Cliffs (3,000) (Figure 3.1). Dryland and irrigation farming form the main economic base of the region with service and value-adding process industries and tourism providing significant economic and employment benefits.

Urban stormwater and rural drainage is discharged to either the Murray River or a series of retarding and drainage basins for evaporation. This section describes the main environments receiving urban stormwater and rural drainage and includes an assessment of their environmental, cultural and heritage, amenity, recreational and economic values.

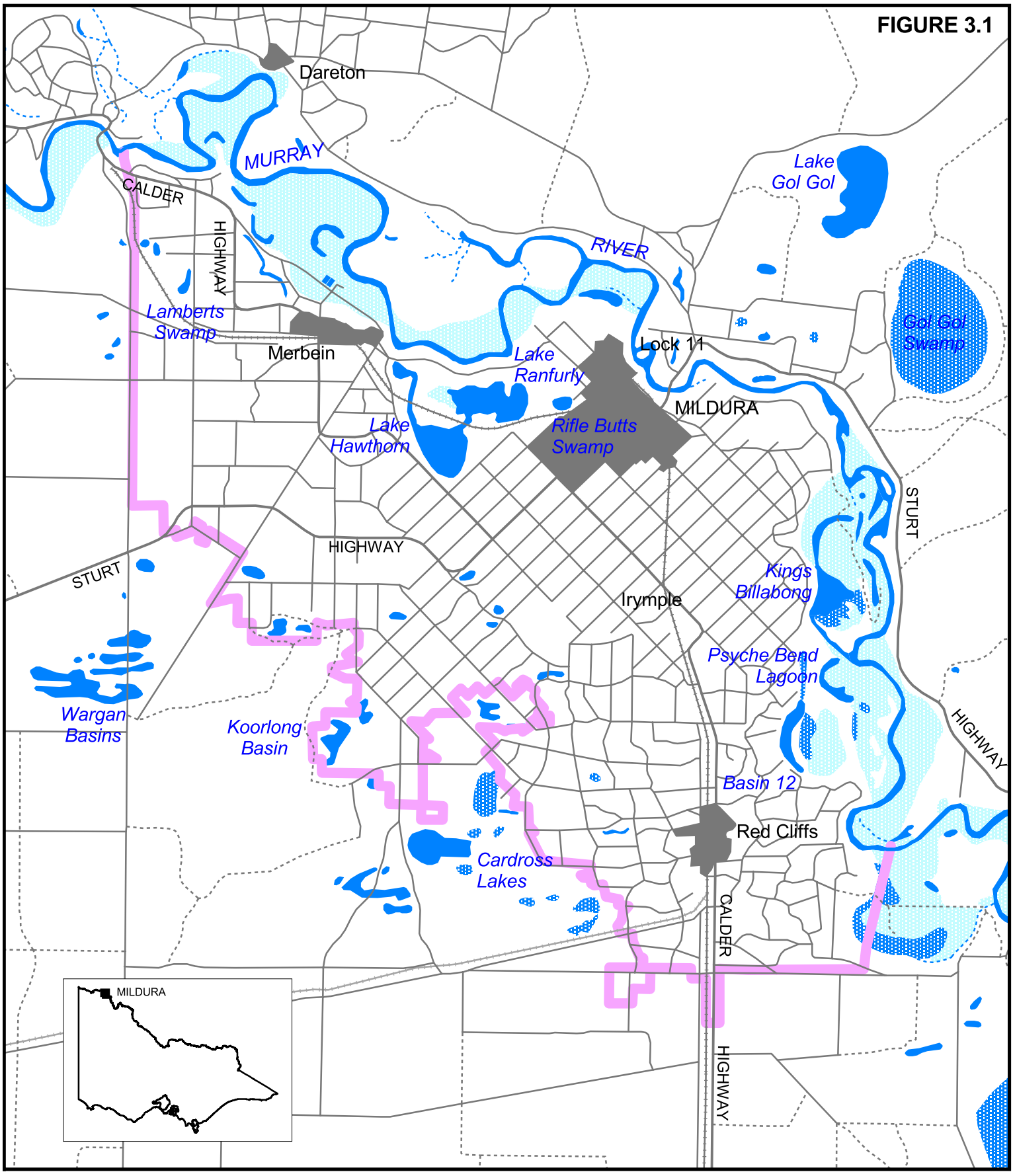
Urban stormwater is the runoff from urbanised areas in Merbein, Mildura, Irymple and Red Cliffs. Mildura Rural City Council (MRCC 2001) has identified thirty-one subcatchments that drain urban areas or proposed urban areas in Mildura and Irymple. The urban areas of Merbein and Red Cliffs are drained by several small subcatchments. A detailed description of the urban stormwater system can be found in the Current Situation Report (MRCC 2001) and Issues Paper no. 1 – Background Review (SKM 2001). The main urban subcatchments, land use and receiving environments are summarised in Table 3.1. Subcatchments locations are identified in Figure 3.2.

Table 3.1. Urban stormwater receiving environments in the study area

Urban area / subcatchment	Main land use activity	Receiving environment
Mildura and Irymple		
Subcatchment A, B & D	Residential	Murray River below Lock 11
Subcatchment E, F, G, H, I, & L	Residential, commercial & industrial	Murray River above Lock 11
Subcatchment J, K & X	Residential & new development	Riffle Butts Swamp
Subcatchment Q1, Q2, Q4, T, Y and Z1	Residential, commercial and new development	Lake Ranfurly East via 15th street drain and Calder retardation basin
Subcatchment Z2	New development	Lake Hawthorn via FMIT drain and Centennial Park retardation basin
Subcatchment M, N, O, P, R, S, U, V, W, Q3, AA and AB	Little or no urban development	Little or no urban drainage infrastructure
Merbein	Residential, industrial & commercial	Murray River Floodplain north of township (little if any urban stormwater would make its way directly to the Murray River)
Red Cliffs	Residential, commercial & light industrial	Basin 12 & Retarding Basin near Nardoo Street

The rural subsurface drainage system collects subsurface flow predominantly associated with irrigation operations. The rural surface drainage system collects overland flow during rainfall events from roads and rural residential areas that don't have a piped stormwater system. A detailed description of the rural subsurface and surface drainage systems can be found in the Current Situation Report (MRCC 2001) and Issues Paper no.1 – Background Review (SKM 2001). Non-urban drainage systems have not been considered for this stormwater management plan.

FIGURE 3.1



SINCLAIR KNIGHT MERZ

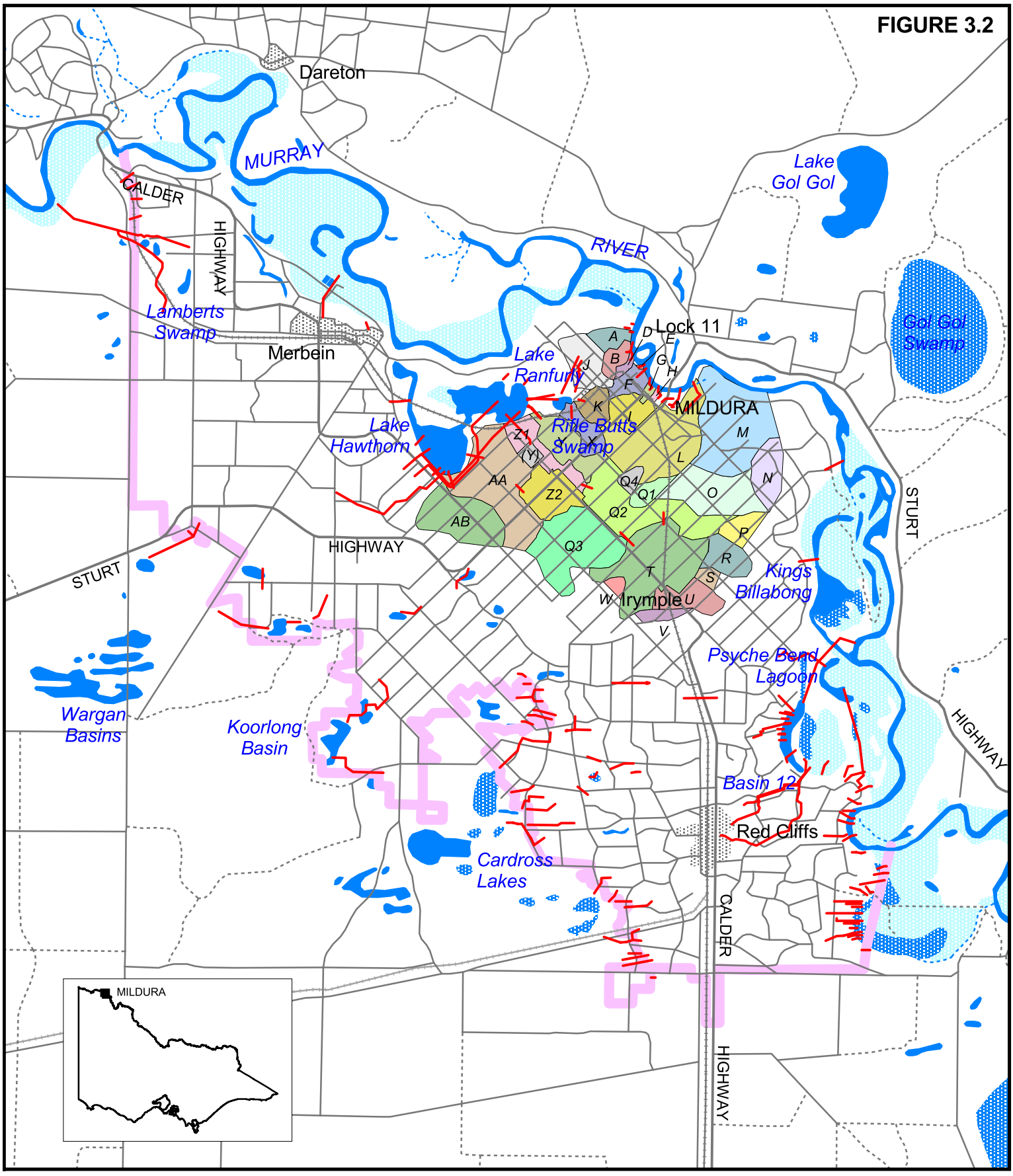
AUSLIG

Refer to Sinclair Knight Merz document
WCMA\wc01738\gis\arcview\c01738t003.apr; Study Area (Layout)

Sunraysia Drainage Strategy and Urban Stormwater Management Plan

STUDY AREA

0 1 2 3 4 5 Kilometers



SINCLAIR KNIGHT MERZ

AUSLIG

Refer to Sinclair Knight Merz document
WCMA\wc01738\gis\arcview\c01738t003.apr; Urban Catchments (Layout)

Sunraysia Drainage Strategy and Urban Stormwater Management Plan

URBAN CATCHMENTS

0 1 2 3 4 5 Kilometers

3.1 Murray River Disposal

3.1.1 Murray River and Floodplain

The Murray River below Lock 11 receives urban stormwater runoff from residential areas in northwest Mildura and irrigation drainage water from around Merbein and Yelta. The major irrigation drainage water input is via the combined northwest and west drains west of Merbein. Urban stormwater from Merbein discharges to the Murray River floodplain below Lock 11 but does not make it directly to the River as the discharge is dispersed across a wide section of the Merbein Common floodplain. There are occasional releases of water from Lake Hawthorn to the Murray River between Mildura and Merbein depending upon flow conditions in the Murray River and the level of Lake Hawthorn.

Flow into this section of the River is controlled by the operation of the Mildura Weir. However, the River level is impacted upon by the operation of the Wentworth Weir. During summer, flow through the Mildura Weir is typically low as most of the water supply to the Murray River below Wentworth is via the Darling River and Menindee Lakes system. Water is drawn from this section of the Murray to provide irrigation and town water supply around Merbein and Yelta.

The Murray River above Lock 11 receives urban stormwater runoff and irrigation drainage water from Mildura via several direct drains. It also receives combined irrigation drainage water and urban stormwater from the Red Cliffs area via Basin 12. Water is pumped from the Murray River for irrigation supply at Red Cliffs and Merbein by SRWA. Water is also pumped from the Murray River at Psyche Bend into Kings Billabong and then into the FMIT supply system. Lower Murray Water Authority (LMWA) pumps water from the Mildura weir pool at Mildura for domestic supply purposes and are proposing to pump additional water from the Murray River below Lock 11 to augment Mildura's town supply. Lower Murray Water Authority also pumps water from the Murray River at Red Cliffs for domestic supply purposes.

The flow into the Mildura Weir pool is controlled by the operation of Euston Weir. During summer, the flow through the Mildura weir pool can be very low. Warm water temperature, low flow and calm weather conditions can contribute to the stratification of the water column in the weir pool producing conditions suitable for the development of blue-green algal blooms. There have been 31 algal blooms recorded in the Murray River between Robinvale and Merbein since 1991 (Egis Consulting 1999). Researchers from the Murray-Darling Freshwater Research Centre Lower Basin Laboratory in Mildura are currently undertaking investigations to improve the management of flow through the Mildura Weir pool by manipulating the flow output from Euston Weir in an effort to prevent stratification from developing in the Mildura Weir pool.

Nutrient loads entering the Murray River in the Mallee region have been calculated as part of the Mallee Catchment Management Authority's Water Quality Management Plan for the region (Egis Consulting 1999, SMEC and LEC 2000). These reports identified elevated nutrients in the Murray River. Upstream inflows were the main source of high nutrients with only 1% of the total phosphorus and total nitrogen loads in the Murray River in the Mallee region sourced from within the region. However, during low flow conditions in the Murray River, nutrient inputs from irrigation and

stormwater drainage may be significant. Within the Mallee region, runoff from dryland cropping, public spaces and dryland pasture carry the greatest nutrient loads.

Stormwater runoff from urban areas and parks and gardens, and irrigation drainage water are the greatest sources of nutrients entering the Murray River within the immediate study area. The Mallee Catchment Management Authority has been monitoring the quality of stormwater entering the Murray River from several urban drains in Mildura. Results from 2000/2001 indicate that salinity and pH levels are unlikely to impact upon the Murray River however, orthophosphate and turbidity in stormwater is generally elevated and could be contributing to potential water quality problems in the direct vicinity of the outfalls (Table 3.2). This is particularly important in the Mildura Weir Pool during low river flow periods.

Table 3.2 Water quality results from stormwater drainage outfalls to the Murray River (Mean of values from December 1999 to March 2001, data provided by the Mallee Catchment Management Authority).

Drain	Sub-catchment	Main land use	EC (uS/cm)	Ophos (mg/L)	pH	Turbidity (NTU)
Etiwanda Ave	L	• Industrial • Commercial • Residential	582	0.25	7.8	172
San Mateo Ave	I	• Commercial • Residential	703	0.06	7.6	35
Magnolia Ave	H	• Commercial	225	0.23	7.8	147
Orange/Madden Ave	G	• Commercial	372	0.11	7.8	74
Rural Dve	A	• Residential	512	0.39	7.7	67
Murray River at Red Cliffs (mean for year 2000)[a]			256	No data	7.3	38

a Sourced from the Victorian Water Quality Monitoring Network Data Warehouse www.vicdata.net

The results also indicate the quality of water discharged from the San Mateo Drain is better with regards to phosphorus and turbidity than any of the other drains however, salinity is slightly elevated. The San Mateo Drain runs through a wetland prior to discharging to the Weir Pool and the results suggest this wetland is helping to reduce the nutrient and sediment loads in the outfall. The slightly increased salinity in the San Mateo drain outflow is most likely due to the concentration of salts already present in stormwater as a result of evaporation loss from the wetland. A proposal to construct a new ephemeral wetland to treat the combined flow from the Etiwanda and San Mateo Drains (SKM 1998a) will likely result in a significant improvement in the quality of stormwater discharged to the Weir Pool from these drains.

The Murray River and its floodplain contain significant vegetation communities and provide significant habitat for many aquatic and terrestrial fauna species. The Murray River floodplain between Kings Billabong and the Murray Kulkyne Regional Park is listed on the Register of the National Estate as an Indicative Place (AHC 2001) and has very high botanical and zoological significance. It maintains one of the region's best examples of River Red Gum *Eucalyptus camaldulensis* and Black Box *E. largiflorens* woodland. The understory is largely intact and supports a large number of rare and threatened flora species (AHC 2001).

The Murray River itself provides habitat for several significant aquatic species including a number of rare and threatened species that have been listed under the Victorian *Flora and Fauna Guarantee Act 1998*, the New South Wales *Fisheries Management Act 1994* and the Commonwealth *Environment Protection and*

Biodiversity Conservation Act 1999 (eg. Murray Cod *Macculochella peeli* and freshwater catfish *Tandanus Tandanus*).

The River Murray floodplain forms the Riverine Land System within the Mallee Zone (LCC 1987). Several cultural heritage management surveys and one research project have been undertaken along the Murray River in the study area. In addition, a number of chance recordings of sites have occurred. A review of the results from these studies reveals that Aboriginal occupation patterns within the floodplain reflect the geomorphological complexity of this landscape. Archaeological studies provide evidence of shell-fish gathering and processing, bark removal, tool manufacture and use, and mortuary practices. Currently, the regional archaeological record indicates a semi-continuous Aboriginal occupation of the study area dating back at least to 22,000 years before present and that both economic and socio-cultural change occurred through (Edmonds 1997).

The Murray River is a popular tourist location and has very high recreational and tourism values. Camping, fishing, boating and nature based activities are popular along the river and floodplain. Mildura is a major stop over location for tourists travel to the Murray River and further afield.

The Murray River forms the main pathway for delivering water for irrigation, industrial and residential water supply purposes from storages in the headwaters to irrigation districts and towns in the lower catchments. The economic value of this water is very high. In 1992 figures, 70% of all water used in Australian agricultural production was used in the Murray-Darling Basin, 71% of the total water used for irrigation in Australia was used in the Basin, and the basin supported 41% of Australia's national gross value of agricultural production (Crabb 1997).

The main threats to the Murray River from urban stormwater and drainage are elevated nutrients, salinity and litter. There is limited treatment of urban stormwater and drainage water prior to discharge to the Murray River. Of the urban stormwater drains, the San Mateo Drain passes through a wetland on the floodplain and may be diverted through a new wetland proposed for the Etiwanda Drain if the Mildura Marina is developed. Other drains outflow directly to the river and only the Rural Drive Drain is equipped with a trash rack to screen large debris items before discharging directly to the river.

Irrigation drainage flows directly to the Murray River via the Etiwanda Drain, the Northwest and west drains, the Northeast Drain and from smaller private diverters. There may be potential for some re-use of drainage water prior to discharge depending on the salinity levels and the ability to guarantee a suitable quantity. The cost of new infrastructure however, is likely to be high.

3.1.2 Kings Billabong

Kings Billabong is a permanent open freshwater wetland located on the Murray River floodplain east of Mildura. It is located within the Kings Billabong Wildlife Reserve, which also includes Psyche Bend Lagoon and Basin 12. The water level in Kings Billabong is held consistently high by the FMIT as part of its irrigation supply system. Water is pumped into Kings Billabong from the Murray River at Psyche Bend and is then pumped from Kings Billabong into the FMIT irrigation supply system. Water can also enter Kings Billabong from the Murray River during flood events. Kings

Billabong receives drainage water inflows from FMIT areas and rural surface runoff. This inflow represents approximately 2% of the yearly FMIT diversions to the Billabong from the Murray River (SKM 1996).

Due to large volumes of water diverted to Kings Billabong from the Murray River, the water quality in the Billabong is generally good. Waterwatch data collected in 1999/2000 indicate low salinity and phosphate levels and moderate turbidity levels in the Billabong (SKM unpublished – Draft Waterway Operation Plan for Kings Billabong). The high water level maintained in the Billabong also helps to prevent the inflow of saline groundwater. However, the quality of drainage water entering Kings Billabong is low with salinity around 2,000 EC (SKM 1998b) and orthophosphate around 0.053 mg/L and this has been identified as a threat to the overall water quality in Kings Billabong (Bluml 1992). In addition, runoff from new rural residential development along the western side of Kings Billabong Reserve has the potential to contribute nutrients, sediment and other contaminants to the billabong. These allotments will be on septic tanks and overflow from poorly maintained septic systems may be detrimental to the quality of water in the billabong and potentially impact upon other values.

Kings Billabong is considered one of the most important conservation areas in the Sunraysia district (Bluml 1992) and is listed on the Directory of Important Wetlands in Australia as a high value wetland for its flora and fauna (EA 2001). The wetland supports over 200 species of native birds (including 26 waterbird species), 7 native animals, 26 species of reptile and amphibians, 8 species of native fish and 90 species of native plants. Of these, 23 plant species and 26 animal species are considered threatened in Victoria (Bluml 1992, EA 2001). Of the waterbirds recorded in the area, 4 are listed under CAMBA, 1 under JAMBA and 2 under both agreements (EA 2001). Although the billabong has considerable conservation value, the consistently high water levels have resulted in the permanent inundation of some areas which has caused the death of some River Red Gums while some aquatic species such as *Typha* sp. have established along the edges of the billabong (DCNR 1993).

The wetland area is used extensively for student and community group education programs about wetland ecosystems and the threats posed by salinity. The area is also popular for many recreational activities including camping, fishing, horse-riding, bird watching, boating and nature conservation. The wetland has been used as an irrigation storage since 1896 (EA 2001) with the Psyche Bend Pumping Station and Billabong Pump Station classified as ‘historic’ on the Register of the National Estate for their significance as steam engine pumping stations and links with early irrigation development in the Sunraysia area (AHC 2001).

A survey of the Kings Billabong Wildlife Reserve (Edmonds 1994) identified 24 sites of archaeological significance on the Murray River floodplain, comprising 11 shell middens, 7 scarred trees, 3 surface scatters of stone artefacts, 1 isolated hearth, 1 burial and 1 isolated artefact. All sites were located adjacent to drainage features and on high riverbanks and terraces above normal flood levels, including Psyche Bend itself. Fragmentary middens and surface scatters comprising a series of hearths and associated stone artefacts were located along the high bank of Psyche Bend (Horseshoe) Lagoon, an ancestral river channel feature. Scarred trees were all located on wetlands close to the riverbank.

Economically, Kings Billabong provides a pivotal role in the supply of irrigation water to the FMIT district.

3.1.3 Psyche Bend Lagoon

Psyche Bend Lagoon is located south of Kings Billabong in the Kings Billabong Wildlife Reserve. Psyche Bend Lagoon once received SRWA irrigation drainage water via Basin 12, but is now bypassed and only receives small volumes of irrigation drainage water from FMIT Mid north area drain. Flow between the Murray River and Psyche Bend Lagoon is controlled such that Psyche Bend Lagoon is held at such a level so as to prevent saline groundwater from Psyche Bend Lagoon seeping into the river. During high river flows, water can be diverted through Psyche Bend lagoon to provide some flushing of saline water. As a consequence of the current operating regime at Psyche Bend Lagoon, which is designed to protect the Murray River and Kings Billabong from saline groundwater, the salinity level in Psyche Bend lagoon is 8,000-16,000 EC and is likely to increase over time due to inflows of saline groundwater and concentration by evaporation (SKM 1998b).

High salinity around Psyche Bend Lagoon has resulted in the degradation of the Black box-chenopod vegetation community with replacement by salt tolerant species (Bluml 1992). In some areas there is bare salt-encrusted ground. The lagoon provides some habitat values for native birds.

There are no recreational values associated specifically with Psyche Bend Lagoon, however the lagoon provides some education opportunities aimed at promoting awareness of the environmental impacts of salinity in the region. The area around the lagoon has suffered from erosion due to trail bike and 4WD activity. There are also large amounts of dumped litter and other rubbish.

Psyche Bend Lagoon provides a level of economic value and environmental protection to the Murray River. The current operating regime affords a level of protection to the Murray River from saline groundwater. Also, the discharge of drainage water from the FMIT mid-north drain to Psyche Bend Lagoon provides further protection from salt inputs to the Murray River.

3.1.4 Basin 12

Basin 12 is located south of Psyche Bend Lagoon in the Kings Billabong Wildlife Reserve. It receives the majority of irrigation drainage water and urban stormwater from the Red Cliffs area from where it is flows by gravity into the Murray River, bypassing Psyche Bend Lagoon and Kings Billabong. In high flow, some water can enter Psyche Bend Lagoon from Basin 12.

Basin 12 is relatively saline with levels up to 2,700 EC (Bluml 1992). There are extensive reed-beds across the basin that supports a diverse avifauna, probably similar to that found elsewhere around billabongs and wetlands along the Murray River floodplain.

There is limited access around Basin 12 and recreational activity would be restricted to some localised bird watching. Some new rural residential development is occurring around the Basin with views over the Basin providing residents with visual amenity.

The archaeological survey of Kings Billabong Wildlife reserve (Edmonds 1994) included part of the western edge of Basin 12. No sites were located there although a midden and a previously recorded burial are located on a similar landform to the north overlooking Kings Billabong itself. This landform is the ancestral bank of the Murray River. It is possible that surface and sub-surface sites may exist along the bank adjacent to Basin 12.

Due to the extensive reed-beds in the Basin, some treatment of drainage water and stormwater would occur, including sediment and nutrient removal, reducing the amount of nutrients and sediment entering the Murray River.

3.2 Basin Disposal

3.2.1 Cardross Lakes

The Cardross Lakes system is located west of Red Cliffs and is composed of 6 evaporation basins (Bluml 1992). Until recently, the basins received irrigation drainage water from the Red Cliffs area. However, improvements in irrigation practices, the pipelining of the irrigation supply and the conversion from flood to drip and sprinkler systems, has resulted in a large decline in the volume of sub-surface runoff from irrigation areas and hence a decline in the volume of drainage water discharged to the basins. As a consequence of lower drainage inputs, the water level in the Cardross Lakes has fallen and become more saline (Shirley *et al.* 1997).

Since 1995 fisheries surveys of the Cardross Lakes have confirmed the presence of four species listed on the Victorian *Flora and Fauna Guarantee Act 1988.* These include the Southern Purple-spotted Gudgeon *Morgurnda adspersa*, Murray Hardyhead *Craterocephalus fluviatilis*, Murray Cod and Freshwater Catfish (Shirley *et al.* 1997 and see Appendix A). The Southern Purple-spotted Gudgeon was previously thought extinct in Victoria and classified as endangered in the Murray-Darling Basin (Shirley *et al.* 1997). Because of the high number of threatened species present in the lake, the aquatic community is considered to be of high conservation value. There is potential that the current improved irrigation practices and the subsequent decline in water level in the Cardross Lakes may be threatening the ongoing survival of the fish community of the lakes.

In 1997 a management plan was prepared to identify options for safeguarding the fish community of the Lake, particularly the Southern purple-spotted Gudgeon (Shirley *et al.* 1997). This plan included options for increasing the flow to Cardross Lakes through the purchase of an environmental allocation of water to maintain water levels and reduce the impact of salinity, and the translocation of threatened species. It is unclear to what degree this plan has been implemented, or to the current status of the fish community.

Apart from the significance of the fish community, the Cardross Lakes provide habitat for birds, opportunities for recreational activities such as fishing and bird watching and are likely to be associated with archaeological sites. The vegetation community around the lakes has been impacted upon by saline groundwater, however there are some stands of Belah woodland associated with the lake, a vegetation community considered threatened in Victoria (Bluml 1992). There have been no archaeological surveys of the Cardross Lakes area, however the landform around the lakes may contain some significant sites.

The economic importance of Cardross Lakes as drainage basins has declined due to reduced need for disposal sites, however some drainage water and rural surface runoff is still discharged to the lakes. There is also opportunity to reduce rural surface flooding during rainfall events by using the current sub-surface drainage infrastructure to transport surface runoff during rainfall events to the Cardross Lakes. However, the installation of a new pump on the main drainage pipe to the lakes is needed for this to be effective (Andrew Sinn, SRWA *Pers. Comm.).*

3.2.2 Koorlong Basins

Koorlong Basins are a group of three evaporation basins located south of Mildura that receive drainage water from the FMIT irrigation district. The land around these basins is mostly cleared of vegetation and is heavily grazed by sheep and rabbits (Bluml 1992). As a result, remnant vegetation is in poor condition with little regeneration (Bluml 1992). The basins themselves have expanded over time due to saline groundwater recharge and salt affected land is evident around the basin margins. The salinity of the main basin has reached 30,000 EC (Bluml 1992). There are some reed-beds around the basins that would provide habitat for birds.

Edmonds (1998) has recorded four archaeological sites around Koorlong Basins. All of the sites comprise isolated hearths (fireplaces) or complexes of hearths composed of burnt calcrete heat retainers. Small numbers of stone artefacts were at two of the sites. One of the sites comprised a series of hearths and artefacts overlooking a depression west of the Koorlong Lakes. It is possible this depression may have held minimal water after heavy rains.

Economically, the basins are important for providing irrigation drainage disposal and the reduction in nutrient and salt discharges to the Murray River.

3.2.3 Lake Ranfurly East and West

Lake Ranfurly is located on the Murray River floodplain between Mildura and Merbein. It is a natural floodplain lake that would have filled during high river levels but is now excluded by levee banks. Lake Ranfurly is divided by a causeway into east and west. Lake Ranfurly West contains hypersaline and highly corrosive groundwater inputs from the Mildura-Merbein Groundwater Interception Scheme. Lake Ranfurly East receives less corrosive groundwater and urban stormwater runoff from Mildura but salinity is still elevated reaching 60,000 EC (Bluml 1992). Water from Lake Ranfurly is pumped to Wargan Basins for disposal. Because of the highly corrosive nature of the water in Lake Ranfurly West, separate pipelines are used.

Lake Ranfurly is listed on the Directory of Important Wetlands in Australia for its significant avifauna (EA 2001). It supports a very large and diverse population of waterbirds, frequently reaching 10,000-15,000 individuals (Bluml 1992). A total of 117 bird species have been recorded including 26 species considered threatened or listed under international migratory bird agreement (ECOS 2001 and see Appendix A). The Directory of Important Wetlands listing does not distinguish between the east and west portions of the lake, however anecdotal evidence and observations during field inspections indicate that waterbirds readily utilise both parts of the lake.

The vegetation around Lake Ranfurly is generally degraded due to the highly saline nature. There are reports of attempted revegetation projects that have failed due to insufficient quantities of water for growth (ECOS 2001).

There have been no systematic archaeological surveys undertaken of Lake Ranfurly and Lake Hawthorn (Section 3.2.4), although a human burial is recorded from the southern edge of Lake Ranfurly. Given that these lakes are features of the ancestral floodplain their margins are likely to be of high archaeological sensitivity although the potential for discovery of Aboriginal sites will be lowered due to the high amount of rural and urban disturbance.

Irrigation, non-irrigated cropping and residential areas surround parts of the lake. The lake area provides opportunities for bird watching and may contain archaeological sites. Economic values of the lake are reflected in its use as a disposal and transfer site for saline groundwater and urban stormwater providing a level of protection to the Murray River from increased salinity and nutrients.

3.2.4 Lake Hawthorn

Lake Hawthorn is located south of Lake Ranfurly, also on the Murray River floodplain. It receives irrigation drainage water from the FMIT district around Mildura and Irymple and the SRWA district south east of Merbein. It receives some urban stormwater runoff from Mildura and Irymple, however this is likely to increase as more land is developed for residential purposes. Water from Lake Hawthorn is pumped to Wargan Basins and can also be discharged to the Murray River if certain flow conditions are reached. Salinity levels in Lake Hawthorn vary around 2,000-5,000 EC. Urban development in the vicinity of Lake Hawthorn is likely to reduce the overall volume of irrigation drainage water entering the lake however, peak flows will increase as a consequence of an increase in hard surfaces. New housing development along the southern and western shoreline of the lake is also proposed. There is no reticulated sewerage supply system in this area so the use of septic tanks on properties located along the lake shore have the potential to contribute to nutrient loads entering the lake.

Three plant species located around Lake Hawthorn are considered threatened in Victoria (ECOS 2001). There is also a woodland area located along the outlet between the lake and the Murray River. This woodland area is likely to contain diverse vegetation and provide suitable habitat for a range of bird species (ECOS 2001). As with Lake Ranfurly and the Wargan Basins, there are records of large numbers of waterbirds at Lake Hawthorn, including many threatened species (ECOS 2001 and see Appendix A). In addition, because of its relatively low salinity, several fish species have been recorded in Lake Hawthorn, including four threatened species (ECOS 2001).

Lake Hawthorn provides a range of recreational opportunities including boating, fishing and bird watching. The amenity of the area will become more important as housing development occurs around the lake. This amenity could be improved by revegetation and the establishment of open space areas around the lake for passive recreation and nature conservation.

3.2.5 Wargan Basins

The Wargan Basins are a series of five interconnected drainage basins located southwest of Mildura. They were previously dry swales between dunes but are now managed as saline drainage disposal basins. They receive inputs from a number of water sources (MRCC 2001, SKM 2001):

- Urban stormwater from Mildura Rural City Council via Lake Ranfurly East and Lake Hawthorn;
- Groundwater from the Mildura Merbein Groundwater Interception Scheme via Lake Ranfurly East and West;
- Natural groundwater intrusion;
- Irrigation drainage water from Lake Hawthorn; and,
- Local catchment runoff.

The basins are listed under the Directory of Important Wetlands in Australia (EA 2001) as providing high value habitat for large numbers of avifauna. Forty three bird species have been recorded in the wetlands (EA 2001 and see Appendix A) half of which are considered threatened or are listed under international migratory bird agreements. The basins frequently support greater than 10,000 waterbirds (EA 2001). Given the reliable water source to the basins, they provide a refuge for waterbirds during drought years and are considered regionally significant for waterbirds (Bluml 1992). There are no records of invertebrates, fish, amphibians, reptiles or mammals (other than rabbits) from the area (ECOS 2001). This most likely reflects a lack of survey data rather than an absence of these species.

The basins are generally surrounded by saltbush with some sections of Cumbungi *Typa* sp. (ECOS 2001). A total of 99 plant species have been recorded, 73 of which are native and 11 of these listed as rare or threatened (ECOS 2001).

The salinity of inflowing water to Wargan Basins can vary between 5,000 and 100,000 EC depending on the source. Basins 1 and 5 act as terminal basins and have the highest salinity 52,000 and 75,000 EC respectively (Bluml 1992). The remaining basins are holding basins and have lower salinity levels of between 5,000 EC and 75,000 EC (Bluml 1992). Nutrient concentration is likely to be high due to fertiliser runoff in irrigation water (EA 2001) however, there appears to be no water quality data collected directly from the lakes to confirm this.

Given the high numbers of waterbirds, the basins provide excellent opportunities for bird watching and photography. Duck hunting is also popular however, lead shot is considered a potential threat to waterfowl (Bluml 1992, EA 2001).

There have been no systematic archaeological surveys conducted around the Wargan Basins and based on the landform it is predicted they of low to moderate archaeological sensitivity (Section 4.1.2).

As the lakes are operated as evaporation basins for the disposal of saline drainage water, they have a significant economic value and also aid in the protection of the Murray River from excessive nutrient and saline inputs.

3.2.6 Lamberts Swamp

Lamberts Swamp is located west of Merbein. It receives irrigation drainage water and stormwater from the surrounding catchment and some saline groundwater recharge

(Bluml 1992). Salinity levels in the swamp often reach 160,000 EC (Bluml 1992). In the past, water has been pumped from Lamberts Swamp to the Murray River however, this has not occurred in recent years due to reduced inflows.

Vegetation around the swamp has been degraded due to the impacts of salinity and the area generally has low environmental value although significant waterbird populations utilise the swamp from time to time (Bluml 1992).

3.2.7 Other basins

There are many other smaller basin located around the study area that receive drainage water and urban stormwater (eg. Riffle Butts Swamp, Coar's Swamp etc). Many of the issues and values associated with the larger basins are also present at these smaller basins. All basins receive water of relatively high salinity and nutrient concentrations and most receive seepage from saline groundwater recharge. Although saline, they often support diverse waterbird communities and provide some drought refuge during dry years. The inflows of stormwater and irrigation drainage water are often the only source of water to these basins and hence is the main factor supporting any habitat values.

3.3 Groundwater

Runoff that does not drain to the river or drainage basins can percolate through to the groundwater. This is most likely to occur in rural areas where surface runoff is limited and water ponds on the ground for periods of time following rain. In these cases, water either evaporates or infiltrates the soil.

The infiltration of drainage water into the ground is often seen as desirable as it reduces the flow volume in nearby waterways and infiltration provides a degree of water quality treatment. However, in the Sunraysia area groundwater is highly saline and close to the surface at many locations as a consequence of the clearing of deep rooted vegetation, past irrigation and drainage practices and the geology of the region (see Section on Groundwater Status in SKM 2001). Given this, it is generally undesirable to contribute more water to the groundwater as this will put upward pressure on the groundwater mound and result in a potential increase in saline discharge to the Murray River, low points along the floodplain and depressions in the Mallee Dunefield. The use of evaporation basins, the Mildura-Merbein Groundwater Incterception Scheme and the careful management of the Psyche Bend Lagoon are amongst measures aimed at reducing the groundwater mound and preventing saline groundwater from discharging the Murray River. In addition, improvements in irrigation practices are reducing the amount of water infiltrating into the soil, alleviating pressure on the level of the mound.

4. Values of receiving environments

4.1 Values

The receiving environments described in Chapter 3 have a range of values including ecological, social and cultural, recreational, and economic values.

4.1.1 Ecological values

Aquatic, terrestrial and groundwater ecosystems are complex systems with a range of ecological values. They support a diverse range of unique flora and fauna dependent on a range of ecological and hydrological processes and habitat. Interactions between aquatic, terrestrial and groundwater ecosystems are complex with each dependant on the other for healthy functioning. The protection of these ecosystems, the diversity of communities that inhabit them, and the ecological and hydrological processes that shape these systems is a critical requirement of stormwater and drainage management.

Threats to ecological values from stormwater and drainage include changes to hydrological regimes, increased nutrient and other contaminant inputs and loss of habitat value. In the Mallee region, irrigation drainage water poses a particular threat, as it is often high in dissolved salts and nutrients. These impacts threaten native flora and fauna and can lead to a loss of species diversity. The healthy functioning of aquatic, terrestrial and groundwater ecosystems are not only important from an ecological point of view but also underpin other values associated with those ecosystems, such as recreational and economic values.

4.1.2 Cultural and Heritage Values

There is a range of social and cultural values associated with receiving environments. Indigenous and non-indigenous people have strong cultural attachments with waterways, for spiritual and historical reasons. Many waterways and activities or events associated with that environment form part of the psyche of local communities. These aspects are valued highly by communities.

Current archaeological records for the Sunraysia region indicates continuous Aboriginal occupation of the riverine corridor spanning the last 21,500 years (Edmonds 1997). There is a diverse range of site types and site complexes, the location of which appears to be closely associated with features of the two main landforms in the study region, the Riverine Landform and the Mallee Dunefield (LCC 1987). The Riverine Landform comprises the Murray River and floodplain, the Mallee Dunefield is located above the Riverine Landform. Most archaeological sites are associated with the Riverine Landform, specifically riparian zones and waterbodies (Table 4.1).

Currently, information regarding the context of archaeological sites located in the Mallee Dunefield land system is limited but it seems that all known sites occur on aeolian features, such as, dunes, ridges and lakeside sediments within 500 m of a fresh or saline water source (Table 4.2).

■ **Table 4.1 Predictive Model of Site Location and Archaeological Sensitivity by Micro-Environmental Context for the Riverine Plain Landform and Associated Sub-systems (after Edmonds 1999).**

*Micro-Environments	Expected Site Types	Archaeological Sensitivity
Riparian (Ffc2)	Shell middens on high banks/ scarred trees/isolated artefacts/hearths	Moderate
Lagoons, swamps and lake margins (Pf2 and Ffc2)	Shell middens/ scarred trees/ isolated artefacts/ hearths/ surface scatters	High
Floodplain (Ffc2)	Isolated hearths/ scarred trees/ isolated artefacts	Low
Box Plain (Ffc2, Pf2)	Scarred trees/ isolated hearths	Low
Sand Dunes (including lunettes) (PEfc2, Ffc2, Lfc2, Pf2)	Burials/ hearths/ surface scatters/ shell middens	High

*See LCC (1987) for key to sub-systems.

■ **Table 4.2 Predictive Model of Site Location and Archaeological Sensitivity by Micro-Environmental Context for the Mallee Dunefield Land System and Associated Sub-systems (after Edmonds 1999).**

*Micro-Environments	Expected Site Types	Archaeological Sensitivity
Dunes- in lakeside sediments or aeolian ridges within 500 m of a fresh or saline water source (PREfc12, RPEfc2)	Shell middens/ burials/surface scatters/ isolated artefacts/ isolated hearths	Moderate
Dunes-on plains adjacent to depressions (PEfc2)	Hearths/ isolated artefacts	Low-Moderate
Gypseous basins-adjacent dunes and margins (PYfz2)	Isolated artefacts/ isolated hearths	Low

*See LCC (1987) for key to sub-systems.

There are only two previous heritage studies that have involved field survey within the study area. These are Andrew C. Ward & Assoc. (1986), which sought to document sites for an LCC regional review, and Kenderdine (1994), which documented sites specifically related to shipping and trade along the Murray River. Neither study employed a systematic field methodology. Other studies (Bardwell 1980, Penney 1993) involved historical research only, but do assist in defining the main historical themes relating to the study area. These are:

- **Exploration** (1828-1840)

Sites predicted: blazed trees, memorials & historical places (e.g. camp sites & Aboriginal interaction sites).

- **Pastoral settlement and forest grazing** (1843+)

Sites predicted: abandoned station sites, wells, weirs, stock yards, stock routes and cemeteries.

- **Aboriginal communities** (1840+)

Sites predicted: former missions & reserves, 'contact' sites, scarred trees and campsites.

- **Surveying** (1840+)

Sites predicted: blazed trees, survey markers

- **Land communications** (1852+)

Sites predicted: abandoned hotel sites, mail and coach routes, telegraph lines, bridges and punt/ferry crossings.

- **The development of inland shipping and trade** (1853-1904)

Sites predicted: shipwrecks, wharves, slipways, docks, locks, custom house sites and navigation markers.

- **Timber getting** (1859+)

Sites predicted: saw mills, charcoal kilns, transport relics, logging camps and stumps.

- **The development of rural industry and settlement** (1860+)

Sites predicted: abandoned selections, boiling-down works, tanneries, abattoirs, flour mills, research stations, lime kilns, brick works, packing sheds and canneries.

- **Irrigation** (1888+)

Sites predicted: channels, syphons, pumps, pump houses, locks, weirs, water storage facilities and construction camps.

- **Leisure and tourism** (1950+)

Sites predicted: fishing sites, campsites, tourist attractions and monuments.

In total, there are approximately 22 non-indigenous heritage sites/places listed on various registers and/or planning schemes within the study area (Edmonds 1999) including the Mildura Planning Scheme, the Register of the National Estate, the Register of Heritage Victoria, the Historic Buildings Register and the National Trust Register. Most of these sites are buildings that are located in urban/residential precincts, although the Mildura Weir and Lock 11 have been identified as historical sites of significant heritage value.

4.1.3 Amenity and recreational values

Waterways are valued for a their visual and landscape amenity and for a range of recreation activities from passive enjoyment of the environment to more active pursuits of swimming and water skiing.

Passive recreational activities are those that involve no contact with the water. They take place on land adjacent to the waterway and include picnicking, walking and visual enjoyment. Secondary contact recreational activities are those where the body is not immersed in the water but where some contact with water may occur. They include activities such as boating, canoeing, wading and fishing. Primary contact recreational activities are those where the whole body can become immersed in the water. These activities include swimming, diving and water skiing.

The Murray River and permanent wetlands on the floodplain are the focus for recreational activity in the study area including boating, fishing, skiing, camping, bird watching etc. Bird watching is also popular at some of the drainage basin where large numbers of waterbirds flock from time to time.

The type of recreational activity recommended for a particular waterbody depends on the quality of water. In Victoria, the EPA has specified the water quality objectives required for different types of recreational activities (Victorian Government 1988). Stormwater and drainage water can have a significant impact on reducing the quality of water in a waterway and severely impact upon the type of recreational activities suitable for that waterway. For example, stormwater can carry significant bacterial contamination at times and this can reduce the recreational value of the receiving waterway and highly saline inputs can impact on vegetation and reduce the aesthetic values and amenity of wetland areas.

4.1.4 Economic values

Receiving environments have a range of economic values. They have an intrinsic value as a provider of ecosystem services, for example, as a natural treatment system for the disposal of effluent and in providing drainage and flood mitigation services. They also have a range of more quantifiable economic values as a source of water for irrigation, industrial, stock and domestic supply purposes. Many waterways are also the focus of commercial industries such as fishing and tourism.

For the purposes of this study, economic values are considered those that relate to the suitability for water supply and the potential for re-use. The supply of high quality water for domestic, industrial and irrigation purposes is essential to the economy of the region, as is the protection of that supply from impacts that may reduce its economic value to downstream users. In the Sunraysia region there is potential for the re-use of good quality irrigation and stormwater on particular crops such as wood lots. In fact, most treated sewage effluent is now used to successfully irrigate wood lots. The challenge is in identifying suitable activities where re-use water can be used and in securing a sustainable supply of suitable quality.

The economic value to the region from tourism is considered under Amenity values while the protection of economic and environmental values to downstream users is considered under Drainage values.

4.1.5 Drainage values

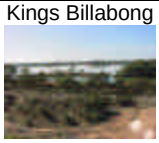
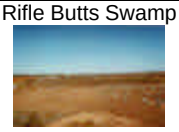
In the Sunraysia region, drainage basins provide an important function in preventing excess salt and nutrients in irrigation drainage water from entering the Murray River. Irrigation drainage water is pumped to evaporation basins where the water evaporates and leaves the salt behind. Other basins also receive saline groundwater from groundwater interception schemes aimed at preventing saline groundwater entering the Murray River. The operation of drainage basins in this manner is designed to protect a range of values including environmental, amenity and economic values within the region and downstream. Inflows to drainage basins is often the only source of water that supports habitat values in those basins. The hydraulic capacity of receiving waters is also important, adequate capacity to cope with inflows from storm events is necessary to prevent local flooding.

The economic values in terms of preventing excess salinity in the Murray River are very high. A credit system is currently in operation in the Murray-Darling Basin such that the prevention of saline water entering the Murray River generates EC credits. Evaporation basins are used to generate EC credits by providing an off river disposal site for saline drainage water and groundwater.

4.2 Specific values of receiving environments

This section identifies and summarises the values of environments receiving urban stormwater runoff and irrigation drainage in relation to the broad values listed above. Values have been identified from relevant literature including environmental investigations, water quality data and waterway condition, regional strategies and management plans and field inspections. Field inspections were conducted of all receiving environments and drainage outfall locations from 26-28 June 2001. The key values of environments receiving urban stormwater water runoff and irrigation drainage are summarised in Table 4.3.

■ Table 4.3 Summary of key values of environments receiving urban stormwater and irrigation drainage

Receiving Environment	Key values
Significant environments receiving urban stormwater runoff	
Murray River 	▪ The Murray River above and below Lock 11 provides significant instream and riparian habitat values. A range of threatened species are supported by the river and floodplain environments and parts of this system are listed on the Register of the National Estate and the Directory of Important Wetlands in Australia. ▪ The Murray River environment is also significant for its cultural and heritage values and there are numerous archaeological sites highlighting the links with indigenous cultures. ▪ The River environment is highly valued for its recreational, tourism and amenity values. ▪ The region is highly dependent on the River as a source of high quality water for irrigation, domestic and industrial use.
Kings Billabong 	▪ As with the Murray River, Kings Billabong has significant instream and riparian values. There is a long record of indigenous contact with the area as well as more recent non-indigenous heritage values associated with irrigation development in the region. ▪ Kings Billabong is listed on the Directory of Important Wetlands in Australia and supports a range of threatened flora and fauna. ▪ The wetlands is a popular for recreational activities including swimming, boating fishing and camping and provides high landscape amenity to rural residential development along the west shoreline. ▪ Water is pumped from the Murray River to Kings Billabong from where it is then pumped into the FMIT irrigation supply system.
Basin 12 	▪ Basin 12 provides habitat values for a range of bird species and offers visual amenity for residential areas, however more active recreational opportunities are low. ▪ Basin 12 is used for irrigation and urban stormwater drainage, however inflows appear to be declining due to improved irrigation practices.
Rifle Butts Swamp 	▪ Rifle Butts Swamp provides a moderate level of habitat for birds. ▪ If managed appropriately, Rifle Butts Swamp offers high amenity values to the community as urban development expands around the wetland. ▪ By directing urban stormwater to Rifle Butts Swamp, inputs to the Murray River are reduced. ▪ The values associated with Rifle Butts Swamp are maintained by stormwater inputs.
Lake Ranfurly East 	▪ Lake Ranfurly East provides significant habitat for many bird species, including species listed under State Government threatened species legislation. It is listed on the Directory of Important Wetlands in Australia for its significant bird habitat. ▪ While the area around the Lake Ranfurly is degraded, there are opportunities for improved amenity for local residential communities. ▪ By directing urban stormwater to Lake Ranfurly, inputs to the Murray River a reduced.
Lake Hawthorn 	▪ Lake Hawthorn provides habitat for birds and some fish species ▪ Lake Hawthorn also provides some recreational opportunities and visual amenity for surrounding residents. ▪ By directing stormwater runoff the Lake Hawthorn, salt and nutrient inputs to the Murray River are reduced.
Significant environments receiving irrigation drainage water	
Cardross Lakes 	▪ Cardross Lakes are significant for supporting one of the most diverse small native fish populations in the State, and in particular the endangered Purple Spotted Gudgeon. ▪ Inflows to Cardross Lakes are declining and reduced water levels in the lakes pose a threat to the native fish species present.
Wargan Basins 	▪ Wargan basins provide significant habitat for a range of bird species and offer a range of passive recreational activities such as bird watching and nature conservation. ▪ The basins are listed on the Directory of Important Wetlands in Australia and support populations of waterbird listed under international migratory bird agreements.

In accordance with the requirements of the Victorian Stormwater Committee guidelines, values have been ranked as low, moderate, high and very high. In order to adequately determine realistic values for each environment, a set of criteria were developed (Table 4.4). Using these criteria, specific values for each receiving environment were ranked. Details of specific rankings and assessment against the above criteria can be found in Appendix B. In addition to current values, an assessment of potential values was also conducted. This assessment was based on the potential change in values of particular environments depending on future management scenarios. These values have been discussed and confirmed with the Project Steering Committee, Reference Group and Working Group and confirmed by the Mildura Rural City Council.

A summary of the current values for all receiving environments is shown in Table 4.5. Generally, all values associated with the Murray River and Kings Billabong are very high. The smaller terminal evaporation basins generally have low environmental value due to highly saline water and reduced volumes whereas the larger terminal basins with a greater water volume have high to very high environmental values because of their significance as habitat for rare and threatened waterbirds. All basins have high drainage value, particularly those that are used to prevent saline and nutrient rich water from entering the Murray River. The highest amenity values are associated with the Murray River, however there is the potential to improve the amenity of many of the drainage basins by revegetation and enhancement of their conservation values. High economic values are associated with the Murray River and with the potential for the re-use of water from some basins depending on the ability to guarantee the quality and quantity of water.

■ **Table 4.4 Criteria for determining values associated with environments that receive urban stormwater runoff and irrigation drainage water**

Ranking	Environmental **Instream flora & fauna** **Ecological processes** **Riparian vegetation**	Cultural **Indigenous cultural sites** **Non-indigenous heritage sites**	Amenity **Tourism** **Recreation** **Education**	Economic **Water supply** **Re-use opportunities**	Drainage **Flood prevention** **Nutrient removal** **Salt interception**
Very high	• Flora & fauna species listed under State or Commonwealth legislation • High biodiversity • Critical habitat or ecological communities listed under State or Commonwealth legislation • Habitat listed on Directory of Important Wetlands in Australia • Sites listed on the Register of the National Estate as 'Natural'	• Archaeological sites listed on the Aboriginal Affairs Victoria register • Sites listed on the Register of the National Estate as 'Historic'	• Important for regional tourism • Activities include Primary Contact Recreation eg swimming • Very high scenic values • Used for educational activities eg nature awareness,	• Water supply for domestic, industrial & irrigation • Re-use opportunities	• High capacity for nutrient stripping • Contributes to EC credits • Flooding prevention • Asset protection
High	• Regionally significant habitat or flora/fauna species • Drought refuge	• High probability of archaeological sites given landform • Sites of local historical significance	• Important for local tourism • Activities include Secondary Contact Recreation eg fishing • High scenic values • Some educational activities	• Water supply for irrigation • Re-use opportunities • Commercial fisheries	• Moderate capacity for nutrient stripping & EC credits • Flood prevention & asset protection
Moderate	• Some habitat values • Locally significant habitat or species	• Low probability of archaeological sites given landform • Minor historical significance	• Limited recreational values • Limited visual amenity	• Water supply for stock • Limited re-use opportunities	• Flood prevention & asset protection
Low	• Low habitat values • No significant flora/fauna • Degraded habitat condition	• No sites	• No recreational values	• Not suitable for water supply	• No capacity for nutrient stripping • No hydraulic capacity

■ Table 4.5 Summary of current values of environments receiving urban stormwater and irrigation drainage

Receiving Environment	Environmental		Cultural		Amenity			Eco-nomic	Drainage	
	Instream	Riparian	Indigenous	Non-indigenous	Recreational	Amenity	Tourism	Water Supply	Flood reductions	Salt & nutrient reductions to Murray River
Environments receiving urban stormwater runoff (& irrigation drainage)										
Murray River	V high	V high	V high	V high	V high	V high	V high	V high	High	Low
Kings Billabong	V high	V high	V high	V high	V high	V high	V high	High	Low	Mod.
Basin 12	High	High	Mod.	Low	Mod.	Mod.	Low	Low	High	V high
Rifle Butts Swamp	Mod.	Mod.	Mod.	Low	Low	Mod.	Low	Low	High	Mod.
Lake Ranfurly East	V high	High	High	Low	Low	High	Low	Low	High	V high
Lake Hawthorn	V high	High	Mod.	Low	High	High	Mod.	Low	V high	V high
Environments receiving irrigation drainage										
Cardross Lakes	V high	V high	Low	Low	Low	Low	Low	Low	Mod.	Mod.
Koorlong Basins	Low	Mod.	Mod.	Low	Low	Low	Low	Low	Mod.	V high
Lamberts Swamp	Low	Low	Low	Low	Low	Low	Low	Low	Low	V high
Lake Ranfurly West	V high	High	High	Low	Low	Low	Low	Low	Low	V high
Wargan Basins	V high	High	Mod.	Low	Mod.	High	Low	Low	V high	V high
Psyche Bend Lagoon	Low	Low	Mod.	Low	Low	Low	Low	Low	Mod.	V high

5. Threats from stormwater and drainage water

5.1 Threats

There is a range of threats to receiving environments from stormwater and irrigation drainage discharge in the study area. These threats and the values they impact upon are summarised below. The impact stormwater threats have on receiving environments is summarised in Table 5.1, specific threats in the study area summarised in Table 5.2.

5.1.1 Sediment

Sediment and soil particles are highly elevated in stormwater and rural surface runoff. Sediment can enter the stormwater system via a number of pathways. Runoff from bare and disturbed ground (eg construction sites, development areas, uncontained stockpiles, carparks and paved areas) carries significant quantities of sediment that are washed in to the stormwater system. Sediment can also wash and fall off vehicles; this deposited sediment builds up on road surfaces and subsequently washes into the stormwater system. Erosion of waterways, drains and unsealed roads also results in increased sedimentation and turbidity.

Excess sediment poses a threat to aquatic ecosystems by smothering benthic surfaces and the organisms that inhabit those surfaces. Fine sediment contributes to turbidity that reduces light penetration. Fine particles suspended in the water column can block fish gills. In addition, nutrients - particularly phosphorus, heavy metals and other contaminants can be strongly bound to sediment particles and hence these pollutants enter waterways attached to sediment particles where they can threaten aquatic ecosystem health and other beneficial values.

Sub-surface drainage water is generally low in suspended material as it has percolated through the soil however, particulate material can become entrained in flow through open earthen channels and where excess surface runoff enters the sub-surface drainage system as a result of flood irrigation practices or rainfall events.

5.1.2 Nutrients

The concentration of the nutrients nitrogen and phosphorus are highly elevated in stormwater and drainage water. There are several key pathways by which nutrients enter stormwater. As indicated above, phosphorus binds to soil and sediment particles and can enter stormwater via erosion, deposition from the atmosphere and runoff from construction sites. Nutrients can also enter the drainage system via fertiliser in runoff from irrigated areas, parks, gardens and recreational areas, particularly golf courses. Sullage and septic tank effluent can contribute significant nutrient loads to stormwater and receiving waterways. Activities such as washing vehicles in the street and allowing the detergent to drain to the stormwater system can also contribute nutrients to waterways. Dog faeces, particularly where they are deposited near to waterways (eg. along foreshores of rivers and lakes) may also contribute excess nutrients.

Excess nutrients in runoff can contribute to excessive algal and plant growth which create eutrophic conditions that can threaten aquatic ecosystem values. Excessive algal and plant growth also threatens other values by increasing the cost of water treatment and restricting recreational activity. The development of toxic blue-green algal blooms can threaten stock and human health.

5.1.3 Salinity

In the Sunraysia region, saline drainage water poses a significant threat to many values and is managed to prevent it from entering the Murray River and contributing to elevated groundwater levels. Elevated salinity levels threatens aquatic communities and degrades vegetation. Agricultural production is impacted upon where saline groundwater is located

near to the soil surface. Elevated salinity in water supply increases the cost of treatment or renders it unsuitable for some applications.

5.1.4 Litter

Litter in stormwater can impact on the visual amenity of a waterway, threaten instream fauna and impact on recreational activities and human health. The main sources of litter entering the stormwater system are around shopping centres and schools where rubbish bins overflow or litter is discarded in the street and subsequently washes into the stormwater system. Litter can also be generated in residential areas, particularly where open 'tub' type recycling bins are used as litter can blow out of these bins, and around construction sites where waste management is often poor.

5.1.5 Organic material

Excessive organic material, including leaves and grass clippings, can enter the stormwater system in runoff. As organic material decomposes it can cause a decline in the oxygen concentration of the water column. A decline in oxygen can negatively impact on aquatic fauna, particularly fish.

5.1.6 Microbiological contamination

Microbiological contamination, namely bacteria, viruses and other pathogens, pose a significant threat to human health, recreational activity and water supply. Microbiological contamination can enter stormwater and waterways via sullage and septic tank discharges in unsewered residential areas. Runoff containing faecal material from sale yards and domestic stock can also contribute to microbiological contamination, as can accidental and emergency overflows from sewerage systems. Infiltration of contaminated stormwater to groundwater aquifers can threaten values associated with groundwater.

5.1.7 Heavy metals and other contaminants

Heavy metals and other contaminants such as pesticides, surfactants, oils and grease can all enter stormwater systems in runoff and from accidental and deliberate discharges. All urban land use areas have the potential to contribute heavy metals and other contaminants however, runoff from industrial areas and major roads are the most likely source of these types of contaminants. In agricultural areas pesticides can enter the drainage system via drift and accidental and deliberate spills.

Heavy metals, oils and grease often become bound in sediments and can threaten aquatic ecosystems. Oil and grease scums impact on visual amenity and recreational values.

5.1.8 Other threats

Other threats from stormwater include impacts on visual amenity by pipes and other stormwater infrastructure. Construction of new stormwater infrastructure, such as pipes and retarding basins, can impact on cultural sites. Inadequate stormwater system capacity can contribute to flooding and health problems. Increases in the area of impervious pavement result in more runoff generation than would be experienced under natural conditions, thus most urban waterways carry a greater flow during storm events than non-urban streams with similar catchment areas. Increased flow can scour stream beds and banks creating erosion and turbidity problems. Poor infrastructure maintenance or design can result in erosion around pipe outfalls and channels.

■ Table 5.1 Summary of effect of stormwater threats on receiving environments.

Key pollutants	Effect on receiving environment
Sediments 	• Excess sediment can smother benthic surfaces and the organisms that inhabit those surfaces. • Fine sediment contributes to turbidity that reduces light penetration. • Fine particles suspended in the water column can block fish gills. • Contaminants such as nutrients and heavy metals can be strongly bound to sediment particles. • Excess sediment can block pipes increasing the risk of flooding.
Nutrients 	• Excess nutrients in runoff can contribute to excessive algal and plant growth. • Excessive algal and plant growth also threatens other values by increasing the cost of water treatment and restricting recreational activity. • The development of toxic blue-green algal blooms can threaten stock and human health. • Excessive algal growth can be aesthetically unpleasing and impact on recreational and public amenity values.
Salinity 	• Saline drainage water and groundwater can negatively impact on many ecological values • High levels kill vegetation and render land unproductive • Detrimental to intolerant fish and vegetation species • Contributes to economic loss through loss of productive land and quality of water supply • Impacts upon amenity and tourism potential
Litter 	• Litter can impact on the visual amenity of a waterway, threaten instream fauna and impact on recreational activities and human health. • Excess litter can block pipes increasing the risk of flooding.
Organic material 	• As organic material decomposes it can cause a decline in the oxygen concentration of the water column and contribute to offensive odours. • A decline in oxygen can negatively impact on aquatic fauna, particularly fish.
Pathogens 	• Microbiological contamination, namely bacteria, viruses and other pathogens, pose a significant threat to human health, recreational activity and water supply.
Heavy metals, oils and grease 	• Heavy metals, oils and grease often become bound in sediments and can threaten aquatic ecosystems. • Oil and grease scums impact on visual amenity and recreational values.
Pesticides and surfactants 	• Pesticides and surfactants can negatively impact on instream flora and fauna values. In particular, surfactants are considered a risk to many amphibian and fish species. • Pesticides can pose a significant threat to human health and impact on recreational values. • Excess pesticides and surfactants can significantly increase the cost of water treatment for water supply purposes.
Flow / Erosion 	• Increased discharge and velocity can scour stream beds and banks causing erosion, sedimentation and high turbidity. • Inadequate capacity in the stormwater systems can contribute to flooding. • Poorly constructed pipe outlets can contribute to erosion.

5.2 Specific stormwater threats

An assessment of the specific stormwater threats in the study area can be found in Appendix C and are summarised in Table 5.2. These threats are grouped according to landuse and particular catchment activities. Specific examples or locations of threats within the region are identified along with the impact expected on receiving environments (Appendix C). As with values, threats have been assigned a ranking according to their significance ie. Very high, High Moderate, Low. This ranking is based on the potential pollutants or impacts on the values of receiving environments. Where a particular threat is not present it has not been given a ranking.

■ **Table 5.2 Threats to receiving environments from stormwater and rural drainage (na: threat not applicable to that environment).**

	Stormwater & Irrigation Receiving Environment							Irrigation drainage Receiving Environments					
Activity/landuse threat	**Murray River below Lock 11**	**Murray River above Lock 11**	**Kings Billabong**	**Basin !2**	**Rifle Butts Swamp**	**Lake Ranfurly East**	**Lake Hawthorn**	**Psyche Bend Lagoon**	**Cardross Lakes**	**Koolong Basins**	**Lamberts Swamp**	**Lake Ranfurly West**	**Wargan Basins**
Residential runoff	V high	V high	High	High	V high	V high	High	Low	Low	Low	Low	Low	na
Industrial runoff	Mod.	V high	na	Mod.	Mod.	High	Low	na	na	na	na	na	na
Commercial / institutional runoff	Mod.	V high	na	Mod.	High	V high	Low	na	na	na	na	na	na
Construction sites – lot	High	High	High	Mod.	High	High	High	na	na	na	Low	Low	na
Development sites	High	High	High	Low	V high	V high	V high	na	na	na	na	Low	na
Major highways, arterial & rural road runoff	High	V high	Mod	High	High	V high	High	na	Low	Low	Low	Low	na
Sullage and septic tank overflows	High	High	V high	High	Mod.	Mod.	High	Low	High	High	High	Low	na
Sewer overflows	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	na
Open spaces, parks and recreational areas	Mod.	High	Mod.	High	High	High	High	Low	Low	Low	Low	Low	na
Upstream inflows	High	High	High	na	na	na	na	na	na	na	na	na	V high
Irrigation drainage	V high	V high	High	V high	Mod.	V high	V high	High	V high	V high	V high	V high	Mod.
Rural surface runoff	V high	V high	High	V high	Low	High	V high	Mod	V high	V high	V high	V high	High
Unstable & degraded waterways	Mod.	High	High	Mod.	Mod.	Mod.	Mod.	High	Mod.	Low	Low	Mod.	Low

The greatest threats from stormwater and drainage water in the study area are due to:

- Excess nutrients in stormwater runoff from residential and industrial areas entering the Murray River;
- Runoff from roads;
- Septic tank effluent;
- Litter in stormwater runoff from commercial areas;
- Poor sediment control on development and construction sites; and,
- Damage to cultural sites, riverbanks, riparian vegetation and wetland areas through degradation by changed flow, erosion, uncontrolled vehicle access, vandalism and rubbish dumping.

Irrigation drainage and runoff from agricultural lands also pose a significant threat to the values of receiving environments. Agricultural runoff can carry nutrients, sediment, salt and pesticides. In the Mildura area most irrigation drainage and urban stormwater drainage systems are separate, although the receiving environments suffer from the combined impacts of stormwater and irrigation drainage water. Although irrigation drainage has been identified as a threat to values of receiving environments, measures to address irrigation drainage and runoff from other agricultural areas are outside the scope of strategies developed in this plan.

5.3 Flooding

In addition to the stormwater and drainage threats identified above, local surface flooding is a significant threat in the study area. Local surface flooding occurs in both urban and rural areas, generally as a result of insufficient capacity in the drainage system to cope with large rainfall events. The study area is undulating to flat and many areas are landlocked with no natural drainage lines such that during runoff events surface flow gravitates to the lowest point and either infiltrates the soil or evaporates. While annual rainfall is low, intense rainfall events often result in rapid runoff and accumulation of surface water that does not freely drain. Levees along the Murray River provide protection to low lying areas from flooding as a result of high flows in the Murray River.

Throughout the urban areas retarding basins have been constructed on major drainage lines and in new subdivisions in an attempt to slow flow down and prevent the capacity of the stormwater system from being exceeded. In many areas urban development has expanded without concurrent upgrades in the stormwater drainage system, for example along Fifteenth Street (see TGM 2001b). Anecdotal information suggests that this is causing an increase in the frequency of flooding in urban areas.

In addition, there are many locations in the study are where inadequate surface drainage in rural areas is contributing to surface flooding of roads, houses and agricultural land. The construction of irrigation supply and drainage channels, roads and the railway line has also created drainage problems by blocking surface flow pathways further exacerbating flooding problems. In some areas, illegal connections from surface drains to the sub-surface drainage system contribute to flooding, especially during the irrigation season when sub-surface drains have little capacity to cope with excess surface runoff.

There have been several reports prepared for the Mildura Rural City Council and its predecessors on urban and rural surface flooding issues, there are also many reports from the public identifying problem flooding areas. Mildura Rural City Council has compiled a list and maps identifying specific flooding locations around the municipality (Mildura Rural City Council, Ordinary Council Meeting Agenda, Stormwater Drainage – 15 Jun 2000), the most significant of these, and the ones that have been subject to previous investigations are summarised in Table 5.3.

While surface flooding has been identified as a threat in the study area, it has not been considered as part of the strategy development in the stormwater management plan. Even so, the Council should initiate a process of mapping the areas of significant inundation and prepare a Special Building Overlay within the Mildura Planning Scheme to identify areas of surface flooding and restrict development in those areas. The Sunraysia Drainage Strategy is providing guidelines for assessing individual local surface flooding problem areas as they are identified.

■ Table 5.3 Summary of urban and rural surface flooding problem areas

Location	Issue	Cause	Possible actions	Reference
Elizabeth & 15th Sts, Mildura	Flooding in Elizabeth St	Surcharge from 15th St drain due to inadequate capacity. Urban development along 15th St has increased without concurrent upgrades in drainage capacity	• Duplicate 15th street Drain • Divert part of 15th dtrain to the proposed 16th st drain	(TGM 2001b)
15th & Koorlong, Irymple	Flooding of road & shops at intersection	Inadequate capacity in drainage system due to increased development and degraded infrastructure	• Upgrade 15th St pipeline capacity • Upgrade pump capacity	(CMPS&F 1994a)
15th St, Sandilong to San Mateo Av (Basin Q2)	New development proposals require drainage system upgrade	Inadequate capacity in 15th St drain to cope with highway duplication and new industrial and residential development	• Enlarge Calder drainage basin to 100 year level • Construct new (Benetook) retarding basin	(CMPS&F 1995) (TGM 2001a)
Indi Ave, Red Cliffs	Overland flow along Indi Ave and ponding of water alongside irrigation channel	Inadequate drainage capacity given landlocked nature of catchment	Construct drainage basin Upgrade pipe capacity	(CMPS&F 1994b)
Morpung Ave, Irymple	Surface flooding of house on south eastern side of railway line	Railway line embankment prevents water from draining away from house thus causing flooding	Culvert through railway embankment	Resident complaint
Coorong & Myall Sts Redcliffs	Flooding at intersection	Road acts as a dam and water floods over agricultural land. SRWA sub-surface drain runs under intersection and illegal surface connections to drain can cause surcharge in area, further contributing to flooding. There is a pump on this drain but it is inadequate to cope with the required flow	Install second pump to move water more quickly along SRWA drain. Drain discharges to Cardross Lakes and has excess capacity due to water use efficiencies and the piping of the supply system	Resident complaint Andrew Sinn, SRWA

6. Risk Assessment and Priority Management Issues

The Victorian Stormwater Committee has prescribed a risk assessment process that must be followed when prioritising management issues for SWMP development. The risk assessment is based on a formula that takes into account the value of the receiving environment, the stormwater threat and a sensitivity factor of the receiving environment to specific threats:

Risk = Threat x Value x Sensitivity

As presented in the pervious sections, values and threats have been ranked on a 1 to 4 scale with 1 being low, 2 medium, 3 high and 4 very high. The sensitivity rating is also based on a 1 to 4 scale with 1 being low sensitivity through to 4 being very high sensitivity. The sensitivity factor allows for the fact that some stormwater threats may be high and the value of the receiving environment also high, however the true impact, or sensitivity is low. For example, the threat from industrial runoff is very high, the value of the riparian zone in the receiving environment is also high but the impact of industrial runoff on riparian vegetation is lower than it is for the instream environment. Thus, the riparian vegetation has a lower sensitivity to industrial runoff than the instream environment. Another example of a high threat / value combination with low sensitivity might occur where the impact of the threat occurs downstream of a particular value.

The sensitivity factor is determined individually for each receiving waterway based on expert opinion and knowledge of the specific values and threats for that environment. Guidelines to assist in the determination of the sensitivity factor are summarised in Appendix D.

The risk assessment produces an overall risk score from 1 to 64 for individual threat/value combinations. The higher the risk score, the greater the management priority thus the risk scores are used to identify the highest priority management issues. In addition, individual risk scores can be summed for each threat and value to produce a total score that identifies the greatest overall threat for a particular receiving environment and the value most threatened.

This process has been applied to each of the receiving environments in the study area. Some of the priority management issues are specific for particular catchments while others are priority issues across all catchments. Risk assessment matrices for each receiving environment are presented in Appendix E. Management issues with a risk score of greater than 32 are listed in Table 6.1, these are considered the high (risk score 32 & 36) and very high priority (risk scores 48 & 64) management issues. The summed threat score is included to help prioritise threats within each risk category. The higher the total threat score the greater the overall threat and impact on values.

Threats from irrigation drainage inflows either through change in quantity (eg Cardross Lakes) or change in quality (Murray River) have also been identified in the risk assessment process (Table 6.2), however specific actions have not been developed to address these risks. The environmental impacts of irrigation and groundwater are dealt with in other strategies and plans being developed in the region.

■ **Table 6.1 Priority management issues and risk scores for threats from urban stormwater runoff to receiving environment**

Risk	Total score	Catchment	Threat	Value	Other values address
64	352	Murray River above Lock 11	Industrial Runoff (Etiwanda Drain)	Ecological, recreational, water supply	Visual amenity (48), riparian, tourism (32)
64	336	Murray River above Lock 11	Road runoff (Deakin Ave, 7th St, Sturt Hwy)	Ecological, water supply	Recreational, visual amenity (48), Riparian, tourism (32)
64	308	Kings Billabong	Sullage and septic tank overflows	Ecological, recreational	Tourism, water supply (36), visual amenity (32)
48	312	Murray River above Lock 11	Degraded waterways (At drain outflows)	Riparian, cultural	Ecological, recreational, visual amenity, water supply (36)
48	304	Murray River above Lock 11	Commercial runoff (Langtree / Pine Av Drain)	Ecological, recreational, visual amenity, water supply	Riparian, tourism (32)
48	288	Murray River above Lock 11	Residential runoff	Ecological, recreational, visual amenity, water supply	Tourism (32)
48	272	Murray River below Lock 11	Residential Runoff (Merbein and Washington Ave)	Ecological, recreational, water supply	Tourism, visual amenity (32)
48	240	Murray River above Lock 11	Construction site runoff – development	recreational, water supply	Ecological, visual amenity (36)
48	237	Kings Billabong	Degraded waterways	Indigenous cultural	Ecological, non-indigenous cultural (36)
48	220	Wargan Basins	Quality of inflows from Lakes Hawthorn and Ranfurly	Ecological	Riparian (48)
48	204	Murray River above Lock 11	Sullage and septic tank overflows	Primary and secondary Recreational activities	Water supply (36)
48	204	Murray River below Lock 11	Sullage and septic tank overflows	Primary and secondary Recreational activities	Water supply (36)
48	160	Lake Ranfurly East	Residential runoff	Ecological	Visual amenity (36), Riparian (32)
48	148	Lake Hawthorn	Construction runoff - development	Ecological	Visual amenity (36), Riparian (32)
48	128	Lake Ranfurly East	Commercial runoff (15th Street precinct)	Ecological	Visual amenity (36), Riparian (32)
48	128	Lake Ranfurly East	Construction runoff - development	Ecological	Visual amenity (36), Riparian (32)
48	116	Lake Ranfurly East	Roads (15th Street and Deakin Ave)	Ecological	Visual amenity (36), Riparian (32)
48	99	Lake Ranfurly East	Industrial runoff (Irymple)	Ecological	
36	216	Murray River below Lock 11	Construction site runoff – development	Ecological, recreational, water supply	
36	216	Murray River below Lock 11	Quality of upstream inflows	Ecological, recreational, water supply	Recreational (36)
36	216	Murray River above Lock 11	Quality of upstream inflows	Ecological, recreational, tourism, water supply	
36	210	Kings Billabong	Construction runoff – rural residential development	Ecological, recreational, visual amenity	
36	207	Kings Billabong	Quality of inflows from the Murray River	Ecological, recreational, water supply	
36	204	Murray River above Lock 11	Construction site runoff – lot scale	Recreation, visual amenity, water supply	
36	198	Kings Billabong	Rural residential runoff (Cureton Ave / Cooke Rd)	Ecological, recreational, visual amenity	
36	192	Murray River above Lock 11	Open spaces, parks and gardens	Ecological, recreational	
36	171	Kings Billabong	Construction runoff – lot scale	Ecological, visual amenity	
36	157	Murray River below Lock 11	Road runoff	Ecological	
36	147	Lake Hawthorn	Residential runoff	Ecological	
36	102	Lake Hawthorn	Sullage and septic tank overflows	Ecological, recreational	
36	102	Lake Hawthorn	Road runoff (Calder Hwy)	Ecological	
36	96	Wargan Basins	Degraded waterways	Ecological	
36	66	Lake Hawthorn	Construction site runoff – lot scale	Ecological	
36	57	Lake Ranfurly East	Open spaces, parks and gardens	Ecological	
32	176	Murray River below Lock 11	Degraded waterways	Indigenous Cultural, riparian	
32	160	Murray River below Lock 11	Industrial runoff (Merbein)	Riparian / floodplain	
32	112	Rifle Butts Swamp	Residential runoff	Ecological	
32	80	Rifle Butts Swamp	Construction site runoff - development	Ecological	

■ Table 6.2 Priority management issues and risk scores for threats from irrigation drainage to receiving environment

Risk	Total score	Catchment	Threat	Value	Other values address
64	336	Murray River above Lock 11	Drainage inflows (northeast drain, Red Cliffs)	Ecological, recreational, water supply	
64	188	Cardross Lakes	Decreased drainage inflows & increased salinity	Ecological	Riparian (48)
48	288	Murray River below Lock 11	Drainage inflows (northwest & west drain, Yelta pd)	Ecological, recreational, water supply	Tourism, visual amenity (32)
48	276	Lake Hawthorn	Changed quality and quantity of drainage inflows	Ecological	Riparian (48), recreational, amenity (36), flood protection (32)
48	236	Lake Ranfurly East	Changed drainage inflows (eg GWIS)	Ecological	Riparian (48), visual amenity (36)
48	200	Lake Ranfurly West	Changed drainage inflows (eg GWIS)	Ecological	Riparian (48)
36	198	Kings Billabong	Changed irrigation drainage inflows (FMIT drain)	Ecological, recreational	
36	184	Basin 12	Changed irrigation drainage inflows	Ecological	

7. Council Management Review

Council's day to day planning and management activities can have a significant effect on stormwater quality. A review of Council's management procedures was undertaken as they relate to stormwater management. This involved a review of the planning approval process, waste management and levels of service, local laws, enforcement and regulation. The review was aimed at identifying areas within Council's management structure where improvements can be made that will have a beneficial impact on stormwater management and quality thus reducing impacts on receiving waterways.

7.1 Key documents and planning tools

There are several documents and planning tools relevant to stormwater management, these include the Municipal Strategic Statement (MSS) and Mildura Planning Scheme, Local Laws and other procedural guidelines. The Council is also in the process of developing a set of Subdivision Development Design Guidelines. In addition there are regional strategies developed by various agencies to assist in guiding broader land use, water quality and environmental management issues in the Sunraysia region.

Specific reference to stormwater management has not been identified as a planning or development issue within the strategic directions identified within the Mildura Municipal Strategic Statement. Although a schedule in the Rural Zone requires a permit to construct or carry out earthworks which may change the rate of flow or discharge point of water across a property boundary or which will increase the discharge of saline groundwater. This clause applies to agricultural activities such as laser grading and tillage as these activities can impact upon the flow of surface runoff.

Section 21.04-3 (Environment) of the Planning Scheme deals with the issue of flooding and drainage, strategies identified within this clause could provide the basis for incorporating Best Practice Stormwater Management into Council's operations. In addition, there is a separate clause relating to the management of land adjacent to the Murray River (Murray River Management Policy, Clause 22.03-1). Incorporation of objectives relating to improved stormwater management and references to the Stormwater Management Plan will improve the ability to incorporate aspects of Best Practice Management, for example into new residential developments.

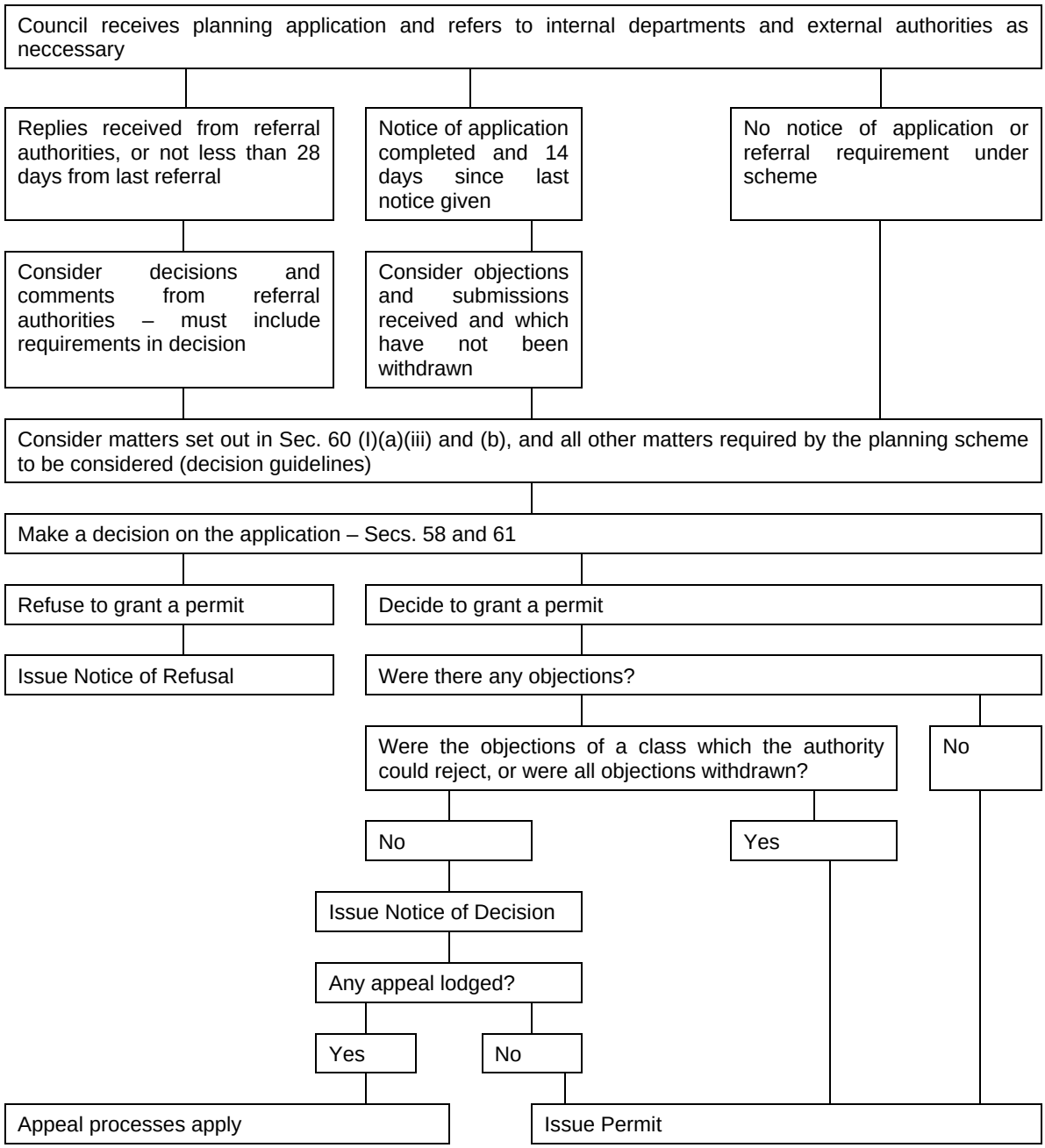
7.2 Planning assessment and approvals

Assessment of drainage and stormwater issues is undertaken by Council and Referral Authorities through the planning process (Figure 7.1). The Mildura Planning Scheme provides development control through the application of zones and overlays throughout the municipality. Applications to use and develop land require planning permits to be approved by Council with the development approvals process controlled by the legislative requirements of the *Planning and Environment Act 1987* and *Subdivision Act 1988*. Council's Planning Department is responsible for the consideration, assessment and approval/refusal of planning applications.

The most common planning application that involves drainage, stormwater and infrastructure issues are a planning application that seeks to subdivide land. Planning

applications involving change or intensification of the use and development applications can also require assessment on stormwater and drainage issues.

Under Clause 66 of the Mildura Planning Scheme certain planning applications have to be referred to nominated referral authorities. The referral of applications is required under Section 55 of the *Planning and Environment Act 1987*, which requires Council to refer planning applications within 7 days and for referral authorities to respond within 28 days of receipt of a planning application.



■ **Figure 7.1 Process for issuing planning permits by Mildura Rural City Council**

Referral Authorities for the Sunraysia Region include all servicing authorities involved in water, sewerage, and power and gas reticulation and Government Departments such as the Department of Natural Resources and Environment and the Mallee Catchment Management Authority. The Planning Department also refers planning applications internally to Council's Infrastructure Department where there is an impact on Council's drainage infrastructure such as an increase in stormwater discharge.

All requirements by Referral Authorities and Council are placed as conditions onto a planning permit, which is issued by Council. Council is then responsible for enforcing conditions of the permit. Should a referral authority inform Council that it objects to a planning application, Council must refuse the planning application (Section 61(2)). Council considers approximately 1000 planning applications per annum.

Key issues identified in the development approvals and referral process that are creating impediments to Best Practice Management are:

- Lack of consistency on advice and requirements received from Referral Authorities and Council;
- Too many staff involved in the assessment process, leading to inconsistent advice;
- Uncertainty in the referrals process and no Council environmental officer available to consider environmental, including stormwater, aspects of applications;
- Referral Authorities requiring conditions to be inserted into planning permits, requiring works to be completed which bear no relationship to the planning application sought. This appears to be a consequence of proponents not providing enough information on applications thus Referral Authorities tends to place a large suite of conditions on applications;
- Poor standard of planning application and the information that accompanies such applications; and,
- Lack of resources and commitment to adequately enforce planning permit conditions.

Some solutions to these issues have already been identified by Council and include:

- Requiring applicants to have pre-application meetings with all Referral Authorities and Council prior to formulating and lodging a planning application;
- Access to information - Referral Authorities and Council having resources required to identify major design and works issues that will affect the development of land; and,
- Appointment of dedicated staff to co-ordinate subdivision and design issues (subdivision officer).

Council is attending to some of these issues with the following:

- Pre-application meetings with applicants on large developments;
- Council is trialing the development of a GIS system, which will place all drainage infrastructure for Red Cliffs onto an electronic database. This will enable Council to then develop models and scenarios for flooding and stormwater inundation, which will assist in design work and consideration of planning applications. It is anticipated that the trial will allow other urban areas to be placed onto an identical system;
- Funding has been set aside for the appointment of a subdivision officer to co-ordinate all subdivision, development and planning issues; and,

- Working with Referral Authorities to identify superfluous conditions and requirements.

7.3 Resourcing, coordination and communication

As indicated above, inconsistent advice and lack of coordination within Council and between Council and Referral Authorities on planning issues exists. This can be overcome with the appointment of a dedicated staff member to coordinate and oversee the approvals process. This would result in a more structured and defined referral process. In addition, internal training and education of Council and Referral Authority staff would help to achieve a consistent approach to Council's overall objectives for stormwater management, better define roles and responsibilities both within Council and Referral Authorities and highlight the particular issues associated with stormwater management that impact upon values of receiving environments.

In addition, it is critical that Council activities and operations that impact upon stormwater and drainage management are adequately resourced. Such activities include routine drainage inspection and maintenance, litter management, street sweeping etc. Internal training that enhances Council staff and contractors awareness of stormwater issues and highlights Council's commitment to stormwater improvement will help to achieve Best Practice Management.

7.4 Regulation and enforcement

Enforcement can be used to complement regulation, management and educational strategies. Typically a range of enforcement options are available including the serving of infringement notices for failing to comply with conditions of a planning scheme or planning permit or breaching a Local Law. Mildura Rural City Council has adopted a range of Local Laws, some of which relate to the prevention of pollution that could impact upon receiving environments or Council's drainage assets and include such issues as:

- Animal faeces being deposited on roads or Council land;
- Material leaking or dropped from vehicles transporting waste material;
- The emptying of bins holding trade waste;
- The discharge of irrigation water or any other water onto Council lands; and,
- The deposition of material such as mud, grease, oil or other substances onto roads or into any drains on or under roads from any vehicle.

Council has the power to introduce additional Local Laws aimed at protecting stormwater quality however, it is important that resources are available such that Local Laws and conditions on planning permits can be enforced. The commitment of resources to enforce Local Laws and planning permit conditions will signal to the community and developers that Council is committed to stormwater management and are prepared to enforce regulations that are aimed at protecting and enhancing the values of receiving environments.

The key management issues identified in the Council review are summarised below. These issues will be discussed and confirmed with the Reference Group and Project Working Group.

Strategic planning

- Revise the MSS and Local Planning Policies to incorporate Best Practice urban stormwater management actions developed as part of this strategy (Revision of the MSS is due in 18 months).
- Strengthen wording within the Local Planning Policy to incorporate best practice stormwater management.

Approvals and Referrals Process

- Clearly define the referrals process.
- Outline roles, responsibilities and triggers for internal referrals eg to environmental officers.
- Develop standard condition requirements relating to sediment and litter control on development and construction sites.
- Incorporate aspects of stormwater best practice management into subdivision development guidelines.

Education and training

- Implement training and education programs for Council staff and contractors to improve awareness of stormwater management issues, roles and responsibilities.
- Clarify roles, responsibilities and jurisdictions amongst Council and Agencies in the region.

Operations

- Establish process for routine inspection and maintenance of drainage infrastructure.

- **Regulation and enforcement**
- Improve regulation and enforcement mechanisms, particularly with respect to the enforcement of planning permit conditions and inspections of development sites during the maintenance period. This requires delegation of powers to appropriate Council officers.
- Develop Local Laws to deal with runoff and litter from construction sites.

7.5 Links between Council management and priority risks

Many of the issues identified in the risk assessment process and the Council management review are closely linked. Council management can directly influence some of the activities that are creating threats to receiving environment values. For example, tighter controls on planning permit conditions that reduce sediment inputs to the stormwater system will have a major beneficial impact upon the quality of stormwater entering receiving environments. It is important that the linkages between the priority risks and Council management are acknowledged so that actions within Council will have a direct improvement on stormwater management at the source rather than solely through reactive measures. The final SWMP will provide Council with the strategic framework required to ensure that best practice stormwater management is at the forefront of Councils operations.

8. Reactive stormwater management strategies

8.1 Strategies

There are two types of stormwater management strategies, **Reactive Management Strategies** (this section) that are developed in response to current threats that relate to priority management issues, and **Management Framework Strategies** (Section 6) that are developed in response to deficiencies identified in the review of Council's management framework.

Reactive Management Strategies can be broadly grouped into the following categories:

- Education and awareness;
- Structural treatment measures;
- Non-structural treatment measures;
- Source controls;
- Site specific strategies and plans;
- Information and data collection; and
- Regulation and enforcement.

While Management Framework Strategies typically address areas of Council operation related to:

- Strategic planning activities;
- Planning and local approvals processes;
- Service delivery levels and improved operations and management activities;
- Opportunities for improved coordination and communication; and,
- Training and education programs.

The following sections summarise the Reactive Management Strategies developed to address each priority management issue. For each priority management issue a strategy objective with a number of actions has been developed. Actions have been categorised according to the following themes:

- Planning controls (P);
- Operations and management (O);
- Regulation and enforcement (R);
- Education and training (E);
- Coordination and communication (C); and,
- Infrastructure solutions and structural control measures (I).

Some of the actions identified in these categories will be effective at addressing a range of issues or threats in a number of locations across the municipality (eg. Education and training, monitoring, regulation and enforcement) while others are specific actions aimed at addressing specific issues (eg. structural control measures). Some structural measures, for example wetlands and gross pollutant traps, will be effective at addressing a number of threats in the one catchment.

To assist with the development of actions, a screening process was used. Table 8.1 presents a range of possible actions within the above themes that could be applied in the Mildura region. Based on these broad actions, specific actions were identified for further assessment.

Table 8.1. Broad management actions used in the screening process to identify actions suitable for the study area.

Threat	Planning	Council Management and Operations	Education and Awareness	Infrastructure
Residential Runoff	▪ Water sensitive urban design for future development ▪ Reduce impediments to composting toilets, household rainwater tanks with toilet or garden reuse, etc	▪ Enforcement/Regulation ▪ Local laws ▪ Street sweeping ▪ Review recycling collections (bin type, frequency) ▪ Review contract wording	▪ Brochures ▪ Waste reduction ▪ Junk mail ▪ School education	▪ Triple interceptor traps ▪ Wetlands ▪ Maintenance of drainage system ▪ GPTs ▪ Reuse Options
Commercial runoff	▪ Permit conditions eg stormwater plan for large centres ▪ Recycling	▪ Litter collection/patrol ▪ Street sweeping ▪ Strategic bin location and type ▪ Local laws ▪ Enforcement of State litter laws ▪ Monitoring	▪ Brochures ▪ Seminars ▪ Target shoppers and shop owners ▪ Drain stencilling eg yellow fish road program ▪ Sponsorship	▪ GPTs ▪ Wetlands ▪ Litter baskets and bins ▪ Commercial recycling within shopping centres (at shop level) ▪ Oil traps on carparks
Industrial runoff	▪ Enforcement ▪ Fines/notices ▪ Conditions on new development ▪ Licenses to discharge to sewage ▪ Requirements for EMPs ▪ Encouraging EPA to enforce regulations	▪ Audits ▪ Local laws ▪ Emergency response plans ▪ Monitoring	▪ Brochures ▪ Audits ▪ Other awareness campaigns eg Green tick ▪ Regular consultation with specific industries	▪ Triple interceptor traps ▪ Wetlands ▪ Bunding ▪ Sewerage disposal eg bypass mechanisms ▪ GPTs ▪ On site detention and reuse options ▪ Decrease impervious surfaces
Development and Construction	▪ Conditions on permits ▪ Referrals process checklist ▪ Pre-application meetings ▪ Guidelines re application requirements ▪ MSS reviews ▪ Environment bond tied to compliance with conditions ▪ Coordination with other councils for standard guidelines ▪ Water sensitive urban design ▪ EMPs for large developments	▪ Enforcement ▪ Sufficient resources ▪ Dedicated SW officer ▪ Local laws ▪ Esp. for lot scale construction eg litter, sediment ▪ See DOI document ▪ Inspections ▪ Check pits	▪ Builders ▪ Developers ▪ Real estate agents ▪ Purchasers (who could apply pressure on builders, developers eg w.r.t. resources material) ▪ Seminars/workshops ▪ Brochures ▪ Resource material	▪ Silt fences ▪ Hay bales ▪ Detention basins and wetlands ▪ Don't connect to drainage until earth works completed ▪ Stock pile control ▪ Washdown facilities ▪ Toilet facilities
Roads	▪ Link with other agencies eg VicRoads ▪ Road design eg CRCCH, VicRoads	▪ Accident response ▪ Sealing road shoulders ▪ Local laws ▪ Vehicle deposition	▪ Transport industry ▪ VicRoads ▪ Vehicle washdown	▪ Swale drains for unsealed roads ▪ Sediment traps / GPTS / wetlands ▪ Revegetate road shoulders ▪ Pervious pavements

In addition, a range of regulatory and statutory options are available to assist in stormwater management

■ **Table 8.2 Regulatory and statutory controls available to assist stormwater management**

Regulatory & Statutory Controls
▪ Environment Protection Act 1970 Works Approvals Licences Research Approvals, Pollution Abatement Notices, Waste transport permits and certificates, Appeal rights
▪ *Litter Act 1987* (EPA)
▪ *Flora & Fauna Guarantee Act 1980* (NRE)
▪ Environment Protection Regulations (EPA) Transport Prescribed waste Landfills
▪ State Environment Protection Policies (EPA)
▪ Industrial Waste Management Polices (EPA)
▪ Victoria's Litter Reduction Strategy (State Gov.)
▪ Regional Waste Management Groups (EPA)
▪ Codes of Practice
▪ Industry
▪ Government

Once the initial screening process had been conducted specific actions were identified. An evaluation of the effectiveness of each management action was conducted based on cost, life cycle, area treated, effectiveness, feasibility and multiple benefit:

$$\frac{\text{Capital Cost} + (\text{Ongoing Cost} \times \text{Lifecycle})}{\text{Effective lifecycle} \times \%\ \text{area treated} \times \text{Effectiveness} \times \text{Feasibility} \times \text{Multiple Benefit}}$$

Where:

- **Lifecycle** is the period of time over which an ongoing cost is incurred
- **Effective lifecycle** is the period of time over which a benefit occurs
- **% area treated** is the area of a catchment that is treated by the particular action
- **Effectiveness** is an indication of how effective the action is at treating the particular threat
- **Feasibility** is an indication of the ability to implement the action give constraints such as location, Council structure etc
- **Multiple Benefit** is an indication of the impact the action has on reducing threats in other areas or against other values

For effectiveness, feasibility and multiple benefit, a qualitative value of Very Low, Low, Moderate, High or Very high is assigned. This corresponds to a quantitative value between 0 and 1. Guidelines for applying the qualitative and quantitative values for different management actions are provided in the Best Practice Urban Stormwater Management Guidelines.

Costs for structural measures are based on market values for purchase, construction and implementation. Costs for non-structural measures are typically based on hourly rates and estimated time. Council will be able to implement many of the non-

structural actions for less than the estimated cost by modifying existing practices or by using internal resources.

Once values have been assigned an overall effectiveness score is calculated and actions for a given threat can be assessed against each other. The lower the score the more cost effective an actions is. Assessment of actions is presented in Appendix F. These actions were discussed with the Project Reference Group and Project Working Group to further refine those suitable for the Mildura region. Based on these discussions and an assessment of the overall effectiveness scores of actions within each strategy, some actions were not recommended for implementation. Actions that passed this screening process have been recommended for implementation.

For each of the priority management issues, recommended strategies and actions are summarised in the following tables (Table 8.3). Provided with each action is an indication of capital and ongoing cost, the authority responsible for implementation and other participating stakeholders, and suggested timeframe for implementation. Where a previously described action addresses a new strategy, linkages are indicated and the costs have not been included as costs only apply once.

Costs for structural measures are based on market prices for supply and installation of suitable structural devices given the pipe size and catchment area, they do not include land acquisition costs. Costs for non-structural measures are typically based on an hourly rate for staff and time involved. Costs are indicative only and will change from time to time, more detailed costing for each action will be required as actions are implemented. In accordance with the VSAP guidelines, land acquisition costs have not been included and in most instances will be low as structural measures are often sited on land that is currently Council owned.

Costs may be significantly reduced if Council staff undertake some of the tasks or by modifying current procedures within Council. The lead agency assigned to each action is not necessarily responsible for the cost, they are just an indication of the agency in the best position to initiate the action.

The establishment of a suitable monitoring program to assess the effectiveness of actions at improving stormwater quality is required as part of the implementation actions identified in this stormwater management plan. Suggestions for a suitable monitoring program including costs are presented in Section 8.2.

■ **Table 8.3. Reactive Management Strategies to address the priority management issues listed in Table 2.4.**

Table legend

- **Theme**: P, Planning,
  O, Operations and management
  E, Education and training
  C, Coordination and communication
  R, Regulation and enforcement
  I, Infrastructure and structural control measures
- **Time**: The time (year) from commencement of the plan by which each particular action should be implemented

Risk	Action	Action	Theme	Time	Cost		Lead agency	Participating stakeholders
					Capital	Ongoing		
64	**A1**	**Objective A1 – Industrial runoff to Murray River above Lock 11:** *To work with the EPA and local industries (particularly those in the Etiwanda catchment) to minimise the risk that runoff from industrial areas has on the environmental, recreational and water supply values of the Murray River above Lock 11.*						
	A1.1	Council should establish long term consultation and coordination with the EPA.	O, C	1		$2,000	MRCC, EPA	Industry groups
	A1.2	Council should initiate workshops for emergency and operations staff both within and external to Council (ie Council emergency response officers, local fire brigade, police, SES personnel etc) to inform workers of the Councils Emergency Response Plan and to outline appropriate management response activities which minimise the impacts associated with discharges from industry to the stormwater system.	O, E	1	$5,000		MRCC, EPA	Industry groups, EPA, emergency services
	A1.3	Council should, in consultation with the EPA and emergency services, update its Emergency Response Plan to ensure that actions to protect the stormwater drainage system and urban waterways from accidental or deliberate discharges are incorporated in the plan.	O	1	$20,000	$2,000	MRCC	EPA, emergency services
	A1.4	Council should initiate workshops and information sessions with industry representatives to highlight best practice stormwater management.	E, O	1	$5,000		MRCC, EPA	Industry groups
	A1.5	Install in-line Gross Pollutant Trap on combined San Mateo / Etiwanda Drain. (Currently proposed as part of marina & wetland project).	I	3	$250,000	$5,000	MRCC	
	A1.6	Construct a wetland for treating runoff from San Mateo and Etiwanda Drains. (Currently proposed)	I	5	$800,000	$10,000	MRCC	
	A1.7	Develop literature and guidelines targeted at industry to highlight issues associated with stormwater runoff and identify areas where industry can help reduce stormwater impacts using best practice management.	E	1	$15,000	$3,000	MRCC	EPA
	A1.8	Coordinate with the EPA to conduct site audits and inspections to ensure industries are complying with relevant State legislation and codes of practice for industrial waste management.	O	1	$5,000	$20,000	EPA, MRCC	
	A1.9	Encourage large industries and new development proposals to develop Environmental Management Plans.	O	3	$30,000		EPA	MRCC

Table 8.3 Cont…

Risk	Action	Action	Theme	Time	Cost		Lead agency	Participating stakeholders
					Capital	Ongoing		
64	**A2**	**Objective A2 – Road runoff from Deakin Av, 7th St and Sturt Hwy to Murray River above Lock 11:** *To work with Vic Roads to reduce the impact of road runoff from major roads on the environmental, recreational and economic values of the Murray River above Lock 11.*						
	A2.1	Establish liaison with Vic Roads to ensure new roads and road upgrades incorporate water sensitive road design features such as grass swales and collector traps.	P	1		$1,000	MRCC	Vic Roads
		Council should initiate workshops for emergency and operations staff.	**See Action A1.2**					
		Update Council's Emergency Response Plan.	**See Action A1.3**					
		Construct Etiwanda wetland.	**See Action A1.6**					
	A2.2	Investigate options for retro fitting major highways with grass swales and detention structures designed to isolate spills.	P, I	3	$15,000		MRCC, Vic-Roads	
	A2.3	Investigate options for addressing risk to LMWA water supply intake from spills on the Chaffey Bridge as identified in a report by GHD	O, I	1	$10,000		MRCC	LMWA, Vic Roads, NSW Roads Board
64	**A3**	**Objective A3 – Sullage and Septic tank effluent from Kings Billabong Low Density Residential Zone** *To minimise the risk of sullage and septic tank effluent from entering Kings Billabong in runoff from low density housing on the western shoreline along Cureton Ave and Cooke St. Sullage and septic tank effluent can contribute excess nutrients and pathogens that would impact upon the environmental, recreational and water supply values of Kings Billabong.*						
	A3.1	Ensure future development in this zone complies with EPA guidelines for onsite wastewater systems. (EPA Publications 629, 746, 747 & SEPP Waters of Victoria) eg Land Capability Assessments.	P	1		$1,000	MRCC	EPA
	A3.2	Develop educational material targeted at residents with septic tanks to highlight the need for regular maintenance.	E	1	$6,000	$2,000	MRCC	EPA,
	A3.3	Construct a wetland on the combined outfall from the rural residential area between Cooke St and Cureton Ave to treat sullage, septic tank overflows and surface runoff prior to discharge to Kings Billabong.	I	5	$300,000	$10,000	MRCC	NRE
48	**A4**	**Objective A4 – Degraded waterways (Murray River and Kings Billabong):** *To reduce the degradation of riparian and instream habitat along the Murray River and Kings Billabong associated with inadequate stormwater infrastructure and uncontrolled access.*						
	A4.1	Liase with NRE, Parks Victoria and the Mallee CMA to manage access to floodplain in order to reduce impact of uncontrolled vehicle access, illegal dumping, live stock grazing etc. Ensure that stormwater impacts are considered in recommendations in Floodplain Management Plans, Frontage Plans and Wetland Management Plans.	O, E	1		$5,000	MRCC	NRE. CMA
	A4.2	Protect riparian vegetation through the establishment of a riparian vegetation protection overlay within local planning provisions.	P	3	$5,000		MRCC	
	A4.3	Inspect all drain outflows along weir pool foreshore and assess for erosion and damaged infrastructure and prepare works plan to rectify problem areas.	O	1	$5,000		MRCC	
	A4.4	Conduct works program for rectifying eroding banks around stormwater outlets (indicative cost).	O, I	1	$50,000	$10,000	MRCC	
	A4.5	Erect signs to raise community awareness of damage that can be done to waterways and vegetation through uncontrolled access, illegal dumping, grazing etc. Link this action with other CMA and NRE initiatives and strategies to promote general awareness of environmental issues.	E	3	$50,000	$2,000	MRCC	CMA, NRE

Table 8.3 Cont…

Risk	Action	Action	Theme	Time	Cost		Lead agency	Participating stakeholders
					Capital	Ongoing		
48	**A5**	**Objective A5 – Commercial runoff from Pine Av Drain (Catchment F) to Murray River above Lock 11:** *To minimise the amount of litter generated in the central business district in Mildura and prevent litter from entering the Murray River above Lock 11 in stormwater runoff from this area.*						
	A5.1	Conduct workshops for Council staff and contractors involved in waste management services, street cleaning and parks and gardens management to promote the initiatives identified in the Stormwater Management Plan across all levels of Council operation.	E, O	1	$10,000		MRCC	
	A5.2	Install a Gross Pollutant Trap on the outfall from Pine Ave Drain to the Mildura Weir Pool.	I	1	$180,000	$7,500	MRCC	
	A5.3	Develop educational material, including street and side entry pit signs and stencils to highlight linkages between what's dropped in the street and the impacts upon the Murray River	E	3	$25,000	$5,000	MRCC	CMA
48	**A6**	**Objective A6 - Residential runoff above Lock 11:** *To work with the local community to minimise the generation of pollutants generated in residential areas and to reduce the impact of residential runoff on environmental, recreational and water supply values of the Murray River above Lock 11.*						
	A6.1	Promote the use of rainwater tanks for watering gardens and investigate feasibility of using grey water for flushing toilets, including an assessment of options for reducing cost to residents associated with adopting water conservation measures eg discounts on rainwater tanks, rates rebate if grey water recycling systems are installed.	P,E	3	$10,000	$1,000	MRCC	EPA
		Initiate workshops for Council staff and contractors.	**See Action A5.1**					
	A6.2	Use the local media to highlight the development of the Stormwater Management Plan and to launch new guidelines and brochures aimed at raising community awareness of stormwater issues.	E	1	$2,500		MRCC	EPA, CMA
	A6.3	Continue to promote Waterwatch and Ecorecycle programs through local schools and ensure stormwater issues are incorporated into these programs.	E	1	$5,000	$5,000	MRCC	EPA, CMA, EcoRecycle Victoria
		Install an in-line Gross Pollutant Trap on the San Mateo / Etiwanda Drain.	**See Action A1.5**					
	A6.4	Assess the potential for litter escape from residential road side recycling bins used around the Municipality, review bin types and instigate a program for converting to enclosed bins if necessary.	O, P	1	$5,000		MRCC	Other Councils
		Construct Etiwanda wetland.	**See Action A1.6**					
	A6.5	Development educational material for residents that promote best practice management and encourage waste reduction. Material can target car washing in streets and driveways, over-use of fertilisers on gardens etc.	E	1	$20,000	$5,000	MRCC	EPA, CMA
48	**A7**	**Objective A7 - Residential Runoff below Lock 11:** *To work with the local community to minimise the generation of pollutants generated in residential areas and to reduce the impact of residential runoff on environmental, recreational and water supply values of the Murray River below Lock 11.*						
		Promote rainwater tanks and grey water reuse.	**See Action A6.1**					
		Initiate workshops for Council staff and contractors.	**See Action A5.1**					
	A7.1	Investigate the feasibility of re-routing the stormwater outflow from Merbein to LMWA treatment ponds.	I	3	$10,000		MRCC, LMWA	
		Use the local media to highlight the development of the Stormwater Management Plan.	**See Action A6.2**					
	A7.2	Install an in-line Gross Pollutant Trap on the stormwater outflow from Merbein township to the Murray River floodplain at Merbein Common.	I	5	$110,000	$5,000	MRCC	
	A7.3	Install an in-line Gross Pollutant Trap on the stormwater outflow from Catchment A to the Murray River below Lock 11	I	3	$80,000	$5,000	MRCC	
	A7.4	Install an in-line Gross Pollutant Trap on the stormwater outflow from Catchments B & D to the Murray River below Lock 11.	I	3	$110,000	$5,000	MRCC	
		Continue to promote Waterwatch and Ecorecycle programs through local schools.	**See Action A6.3**					
		Assess the potential for litter escape from residential recycling bins.	**See Action A6.4**					
		Development educational material for residents that promote best practice management and encourage waste reduction.	**See Action A6.5**					

Table 8.3 Cont…

Risk	Action	Action	Theme	Time	Cost		Lead agency	Participating stakeholders
					Capital	Ongoing		
48	**A8**	**Objective A8 - Runoff from urban development sites (all catchments):** *To work with developers and improve communication and coordination between Council planning staff and external authorities to reduce the amounts of sediment in runoff from urban development sites across the Municipality.*						
	A8.1	Conduct workshops and staff training to ensure that all relevant Council planning staff and external authorities understand referral requirements & procedures under the Planning and Environment Act 1987	P, O	1	$5,000		MRCC	Referral authorities
	A8.2	Conduct workshops for Council staff involved in internal referrals process to ensure appropriate conditions that support best practice management are incorporated into planning permits (eg Sediment control techniques).	P	1	$5,000		MRCC	
	A8.3	Determine applicability of different Water Sensitive Urban Design (WSUD) principles given unique characteristics in Mildura for all new developments (eg detention systems, re-use for watering, swales etc) and require adoption of appropriate WSUD principles for new development through reference to appropriate guidelines eg Best Practice Environment Management Guidelines.	P, E	3	$20,000	$2,000	MRCC	Referral authorities
	A8.4	Conduct workshops and information sessions for developers, builders, contractors and consultants to highlight MRCCs requirements for best practice management and to fully inform developers of information requirements on planning applications.	P, E	1	$10,000		MRCC	Referral authorities
	A8.5	Require developers to prepare sediment and erosion control plans for all new developments. This actions links with **Actions 8.3, 8.4** & **8.6.**	P	1	$20,000	$3,000	MRCC	EPA, CMA
	A8.6	Increase frequency of audits and inspections of development sites and ensure appropriate infringement notification and enforcement of planning permit conditions.	R	1		$30,000	MRCC	
	A8.7	Continue with plan to employ a dedicated Council officer for dealing with urban development and planning issues. Ensure this person is fully conversant with best practice stormwater management principles.	P	1	$20,000	$75,000	MRCC	
	A8.8	Require developers to regularly clean gutters and drainage system during maintenance period to protect Council drain from sedimentation. (Cost is borne by developers).	P, O	1			MRCC	Referral authorities
48	**A9**	**Objective A9 - Inflows to Wargan Basins from Lakes Hawthorn and Ranfurly:** *To ensure the quality of inflows to Wargan Basins are not significantly impacted upon by stormwater runoff.*						
	A9.1	Addressed by managing urban inflows to Lakes Hawthorn and Ranfurly (**Strategies 11-14, 19, 20**)	C				MRCC, GMW	SRWA, FMIT
48	**A10**	**Objective A10 - Sullage and septic tank overflows (all catchments):** *To work with the local community to raise the awareness of the environmental impacts of septic tank systems and to reduce the impacts of sullage and septic tank effluent on environmental, recreational and water supply values in all catchments.*						
		Ensure future development complies with EPA guidelines for onsite wastewater systems. (EPA Publications 629, 746, 747 & SEPP Waters of Victoria).	**See Action A3.1**					
	A10.1	Document unsewered areas and report on potential for environmental problems. Ensure reporting requirements of EPA publication 629 are met.	O	1	$10,000	$500	MRCC	LMWA
		Education for residents on septic tank maintenance.	**See Action A3.2**					
	A10.2	Investigate potential for sewering of or local treatment for problem areas	P,O	5	$15,000	$2,000	MRCC, LMWA	

Table 8.3 Cont…

Risk	Action	Action	Theme	Time	Cost		Lead agency	Participating stakeholders
					Capital	Ongoing		
48	A11	**Objective A11 - Residential runoff to Lake Ranfurly East:** *To work with the local community to minimise the generation of pollutants in residential areas and to reduce the impact of residential runoff on environmental and amenity values of Lake Ranfurly East.*						
		Promote rainwater tanks and grey water reuse.	**See Action A6.1**					
		Initiate workshops for Council staff and contractors.	**See Action A5.1**					
	A11.1	Retrofit old sewerage treatment lagoons on outflow to Lake Ranfurly from 15th Street Drain to provide improved wetland treatment. Investigate the possibility for including outflow from Catchment Y as part of this action.	I	3	$60,000	$5,000	MRCC	GMW, SRWA, FMIT
		Use the local media to highlight the development of the Stormwater Management Plan.	**See Action A6.2**					
	A11.2	Install Gross Pollutant Trap on the 15th Street Drain prior to discharge to Lake Ranfurly East. (May be difficult due to condition of piped drainage system and the need for upgrades in the 15th Street catchment, trash racks on the outfall may provide the best opportunity for managing gross pollutants at this location).	I	3	$150,000	$7,500	MRCC	
		Continue to promote Waterwatch and Ecorecycle programs in schools.	**See Action A6.3**					
		Assess the potential for litter escape from road side recycling bins.	**See Action A6.4**					
		Development educational material for residents that promote best practice management and encourage waste reduction.	**See Action A6.5**					
48	A12	**Objective A12 - Commercial Runoff from 15th Street precinct to Lake Ranfurly East:** *To minimise the impact of litter and road runoff from the Commercial precinct along 15th Street on the environmental and amenity values of Lake Ranfurly East.*						
		Retrofit old lagoons on outflow to Lake Ranfurly from 15th Street Drain to provide wetland treatment.	**See Action A11.1**					
		Install Gross Pollutant Trap on the 15th Street Drain prior to discharge to Lake Ranfurly East.	**See Action A11.2**					
		Develop educational material, including street and side entry pit signs and stencils to highlight linkages between what's dropped in the street and the impacts upon the Murray River.	**See Action A5.3**					
48	A13	**Objective A13 - Road runoff from Deakin Av & 15th St to Lake Ranfurly East:** *To reduce the impact of road runoff from major roads on the environmental, recreational and economic values of the Lake Ranfurly East.*						
		Establish liaison with Vic Roads to ensure new roads and road upgrades incorporate water sensitive road design features such as grass swales and collector traps.	**See Action A2.1**					
		Council should initiate workshops for emergency and operations staff.	**See Action A1.1**					
		Update Council's Emergency Response Plan.	**See Action A1.2**					
		Retrofit old lagoons on outflow to Lake Ranfurly from 15th Street Drain to provide wetland treatment.	**See Action A11.1**					
		Investigate options for retro fitting major highways with grass swales and detention structures designed to isolate spills.	**See Action A2.2**					
48	A14	**Objective A14 - Industrial runoff from Irymple:** *To work with the EPA and local industries to minimise the risk that runoff from industrial areas in Irymple has on the environmental, recreational and amenity values of Lake Ranfurly East.*						
		Establish long term consultation and coordination with the EPA.	**See Action A1.1**					
		Initiate workshops for emergency and operations staff	**See Action A1.2**					
		Update Council's Emergency Response Plan.	**See Action A1.3**					
		Initiate workshops and information session with industry representatives to highlight best practice stormwater management.	**See Action A1.4**					
	A14.1	Maintain trash racks and pumps at Irymple retarding basin	I	1		$5,000	MRCC	
		Develop literature and guidelines targeted at industry.	**See Action A1.7**					
		Retrofit old lagoons on outflow to Lake Ranfurly from 15th Street Drain to provide wetland treatment.	**See Action A11.1**					
		Coordinate with the EPA to conduct site audits and inspections.	**See Action A1.8**					
		Encourage large industries and new development proposals to develop Environmental Management Plans.	**See Action A1.9**					

Table 8.3 Cont…

Risk	Action	Action	Theme	Time	Cost		Lead agency	Participating stakeholders
					Capital	Ongoing		
36	**A15**	**Objective A15 - Upstream inflows to weir pool:** *To coordinate with other authorities to minimise the impacts of upstream inflows in the Murray River from adversely impacting upon the water quality in the Mildura Weir Pool and Kings Billabong.*						
	A15.1	Continue liaison with MDBC and GMW to investigate options for pulsing flows through Euston Weir pool to reduce the potential for algal blooms as recommended by the Mallee Water Quality Strategy & MDBC flows projects.	C	1		$2,500	MRCC, MDBC, GMW	CMA, NRE
	A15.2	Establish long term consultation with regional authorities and upstream Councils to highlight the impacts that upstream activities have on water quality in Mildura as recommended in Mallee Water Quality Strategy.	C	1		$5,000	MDBC, MRCC	CMA, NRE, other Councils
36	**A16**	**Objective A16 – Runoff from lot scale construction sites (all catchments):** *To work with builders and developers to reduce the amounts of sediment and litter in runoff from lot scale construction sites throughout the Municipality.*						
	A16.1	Encourage improved stormwater management at the lot scale by promoting best practice management literature and guidelines (eg Best Practice Environmental Management Guidelines, Construction Techniques for Sediment Pollution Control).	E	1		$3,000	MRCC	DOI, EPA, Industry
		Conduct workshops for developers, builders, contractors and consultants to advice on best practice management techniques.	**See Action A8.4**					
	A16.2	Develop and enforce a new local law based on the Department of Infrastructure Code of Practice for the Protection of Council Assets and Control of Building Sites.	R	1	$5,000	$20,000	MRCC	
36	**A17**	**Objective A17 - Rural residential runoff from Kings Billabong LDRZ:** *To work with the local community to minimise the impact of runoff from the Kings Billabong Low Density Residential Zone to Kings Billabong.*						
		Promote rainwater tanks and grey water reuse.	**See Action A6.1**					
		Use the local media to highlight the development of the Stormwater Management Plan.	**See Action A6.2**					
		Continue to promote Waterwatch and Ecorecycle programs through local schools.	**See Action A6.3**					
		Initiate workshops for Council staff and contractors.	**See Action A5.1**					
		Assess the potential for litter escape from residential road side recycling bins.	**See Action A6.4**					
		Development educational material for residents that promote best practice management and encourage waste reduction.	**See Action A6.5**					
		Construct a wetland on the combined outfall from the rural residential area between Cooke St and Cureton Ave to treat sullage, septic tank overflows and surface runoff prior to discharge to Kings Billabong.	**See Action A3.3**					
36	**A18**	**Objective A18 - Runoff from open spaces, parks and gardens (all catchments):** *To work within Council to minimise the amounts of nutrients and sediment in runoff from Council managed open spaces, parks and gardens across the Municipality.*						
	A18.1	Council should revise the operational and maintenance procedures for open space management in order to reduce fertiliser application rates to parks and garden, improve water use efficiencies through improved irrigation practices and promote the use of plants with low nutrient and watering requirements etc.	O	1	$10,000	$5,000	MRCC	
		Initiate workshops for Council staff and contractors.	**See Action A5.1**					
	A18.2	Council should investigate options for re-use of stormwater for irrigating parks and gardens. Stormwater detention systems could be incorporated into new development and used for watering nature strips, parks and gardens.	P,O	3	$20,000		MRCC	

Table 8.3 Cont…

Risk	Action	Action	Theme	Time	Cost		Lead agency	Participating stakeholders
					Capital	Ongoing		
36	**A19**	**Objective A19 - Residential runoff to Lake Hawthorn:** *To work with the local community to minimise the impact of residential runoff on the environmental and amenity values of Lake Hawthorn.*						
		Promote rainwater tanks and grey water reuse.	**See Action A6.1**					
		Use the local media to highlight the Stormwater Management Plan.	**See Action A6.2**					
	A19.1	Incorporate wetland treatment, grass swales and local detention systems on the proposed 16th street drain	P, I	1	$300,000	$10,000	MRCC	
		Continue to promote Waterwatch and Ecorecycle programs in schools.	**See Action A6.3**					
		Initiate workshops for Council staff and contractors.	**See Action A5.1**					
		Assess the potential for litter escape from residential recycling bins.	**See Action A6.4**					
		Development educational material for residents that promote best practice management and encourage waste reduction.	**See Action A6.5**					
	A19.2	Investigate options for retrofiting Centenary Park Retarding Basin to provide low flow wetland treatment of stormwater runoff.	P, I	3	$50,000	$10,000	MRCC	
36	**A20**	**Objective A20 - Road runoff in Lake Hawthorn, the Murray River below Lock 11 & other areas:** *To minimise the impact of road runoff from major highways and other roads across the Municipality.*						
		Establish liaison with Vic Roads to ensure new roads and road upgrades incorporate water sensitive road design features such as grass swales and collector traps.	**See Action A2.1**					
		Council should initiate workshops for emergency and operations staff.	**See Action A1.1**					
		Update Council's Emergency Response Plan.	**See Action A1.2**					
		Investigate options for retro fitting major highways with grass swales and detention structures designed to isolate spills.	**See Action A2.2**					
32	**A21**	**Objective A21 - Industrial runoff from Merbein to Murray River:** *To work with the EPA and local industries to minimise the risk that runoff from industrial areas in Merbein has on the environmental, recreational and recreational values of the Murray River and Merbein Common wetlands.*						
		Establish long term consultation and coordination with the EPA.	**See Action A1.1**					
		Initiate workshops for emergency and operations staff	**See Action A1.2**					
		Update Council's Emergency Response Plan.	**See Action A1.3**					
		Initiate workshops and information session with industry representatives to highlight best practice stormwater management.	**See Action A1.4**					
		Investigate the feasibility of re-routing the stormwater outflow from Merbein to LMWA treatment ponds.	**See Action A7.1**					
		Install an in-line Gross Pollutant Trap on the stormwater outflow from Merbein township to the Murray River floodplain at Merbein Common.	**See Action A7.2**					
		Develop literature and guidelines targeted at industry.	**See Action A1.7**					
		Coordinate with the EPA to conduct site audits and inspections.	**See Action A1.8**					
		Require large industries and new development proposals to develop Environmental Management Plans.	**See Action A1.9**					
32	**A22**	**Objective A22 - Residential runoff to Rifle Butts Swamp:** *To work with the local community to minimise the impact of residential runoff on the environmental and amenity values of Rifle Butts Swamp.*						
		Promote rainwater tanks and grey water reuse.	**See Action A6.1**					
		Use the local media to highlight the development of the Stormwater Management Plan.	**See Action A6.2**					
		Continue to promote Waterwatch and Ecorecycle programs in schools.	**See Action A6.3**					
		Assess the potential for litter escape from road side recycling bins.	**See Action A6.4**					
		Development educational material for residents that promote best practice management and encourage waste reduction.	**See Action A6.5**					
	A22.1	Install in-line Gross Pollutant Traps on drain outfalls from Catchments J, K & X.	I	5	$250,000	$15,000	MRCC	
	A22.2	Investigate feasibility of collection and reuse of stormwater and drainage runoff on the Mildura golf course.	O	1	$10,000		Golf Course Mngt.	MRCC

8.2 Monitoring

Several routine water quality monitoring programs currently exist in the region; the Statewide Victorian Water Quality Monitoring Program and monitoring of irrigation drains and drainage basins by regional water authorities. There is also some ad hoc monitoring associated with scientific and research studies and community programs such as Waterwatch. While these monitoring programs can provide some data on the water quality status in the region, they are not targeted at monitoring stormwater quality. As such, a suitable monitoring program that specifically targets stormwater quality needs to be developed in consultation with the EPA, Mallee CMA, regional water authorities and other experts in water quality monitoring and environmental assessment, for example staff from Lower Basin Laboratory. The first stage in developing a monitoring program is to identify the water quality parameters that are likely to respond to changed stormwater management practices. For example, constructed wetlands are designed to reduce nutrient and sediment loads in stormwater so a suitable suite of parameters for monitoring constructed wetlands would need to include nitrogen, phosphorus and suspended solids in the inflow and outflow to wetlands. To be most effective at monitoring the impact of improved stormwater management practices, monitoring of stormwater flow needs to be established some time prior to management strategies being implemented in order that a response can be detected when the new management actions are implemented.

Costs for developing and implementing a monitoring program are dependent on the number of samples and suite of parameters analysed. An initial cost of $15,000 would be required to establish a suitable monitoring program that identifies sample locations, parameters and frequency of sampling. The actual sampling costs are dependant on the number of locations sampled, the frequency of sampling and the number of parameters analysed. Laboratory analysis costs for a suite of suspended solids, biological oxygen demand (BOD), nutrients (total nitrogen and phosphorus, oxidisable nitrogen and soluble phosphorus) and heavy metals (eg. lead, cadmium, copper, iron and zinc) are approximately $200/sample. The measurement of in-situ parameters such as turbidity, dissolved oxygen, salinity and pH would require the purchase of a suitable meter or meters. An approximate cost for implementing a routine stormwater-monitoring program based on sampling 10 locations once a month would be $30,000 including travel and expenses. This cost could be reduced if fewer parameters are analysed or if a system for cost-sharing with other monitoring programs in the region is identified.

For monitoring to be most effective, it is important that a suitable sampling program is established at an early stage in the implementation of this stormwater management plan.

9. Council Management Framework Strategies

9.1 Strategies

Based on the review of Council's management framework, a number of recommendations have been made to incorporate Best Practice Stormwater Management into Council's planning and management activities, these are summarised in Table 9.1. Many of these recommendations can be implemented by modifying or improving existing Council planning and management practices. Where recommendations require changes to Council's Municipal Strategic Statement, planning scheme and other strategic and corporate documents scheme, these changes can be made when opportunities arise as part of scheduled regular revisions.

■ Table 9.1 Council management framework actions

Action	Description	Priority
Strategy B1– Assign responsibility for stormwater management *To assign responsibility within Council for implementing the Mildura Rural City Council Urban Stormwater Quality Management Plan and establish long term and Council wide commitment to stormwater management in the Mildura region.*		
B1.1	Council should assign responsibility for implementation of the *Mildura Rural City Council Stormwater Quality Management Plan* to the appropriate Council officer (eg Environment Officer - **Action B1.3**).	Very high
B1.2	Define roles and responsibilities for stormwater management within Council and establish an Implementation Committee to assist the responsible Officer in implementation of the stormwater management plan. Prepare a detailed timetable for implementation based on funding availability and review this schedule regularly.	Very high
B1.3	Establish a position within Council for an Environmental and Stormwater Management Officer who would be responsible for implementing the environmental programs including the Stormwater Management Plan. Duties would include: ▪ Environmental assessment of new development proposals; ▪ Implementation of stormwater education and training programs for Council staff; ▪ Facilitation of stormwater workshops and information sessions for industry and development groups; ▪ Coordination of educational material, literature and guidelines for the local community, schools etc to raise stormwater awareness; and, ▪ Monitoring and review of the stormwater management plan implementation. The Environmental and Stormwater Management Officer would ideally have skills in environmental and stormwater management, water sensitive urban design, education and communication.	Very high
B1.4	Identify funding sources and apply for funding to implement actions identified in the stormwater management plan. Relevant sources of funding include: ▪ Victorian Stormwater Action Program implementation grants scheme; ▪ Natural Heritage Trust & Murray-Darling 2001 funding programs for on ground works; and, ▪ EcoRecycle Victoria funding for waste management, recycling and education programs.	Very high
B1.5	Clarify roles, responsibilities and jurisdiction with regards to stormwater management amongst Council and Agencies in the region.	Very high
B1.6	Council, with assistance from the EPA and Mallee CMA, should develop and implement an urban water quality monitoring program to determine if management actions are effective at improving stormwater quality. Indicative costs for such a program include approximately $25,000 to establish a suitable program, identify appropriate sites and identify relevant parameters for measurement. Approximately $15,000 per year would be required to implement a suitable water quality monitoring program which would include routine monitoring and targeted studies in particular problems areas.	Very high
B1.7	Council should develop a program to assess and review the implementation and effectiveness of stormwater initiatives identified in the Stormwater Management Plan. Reviews should be conducted every 12 months and plans and documents revised as necessary.	Very high

Table 6.1 Cont/..

Action	Description	Priority
	Strategy B2 - Strategic Planning *To ensure best practice stormwater management is incorporated in Council's strategic documents to support Council's objectives for improved stormwater quality and environmental management*	
B2.1	Council should incorporate reference to best practice stormwater management in the Corporate Plan to highlight Council's commitment to improved environmental management.	Very high
B2.2	Council should ensure that State Planning Policy Framework Clause 15.01 Protection of Catchments, Waterways and Groundwater is referred to as part of the development approvals process.	Very high
B2.2	Council should amend the Mildura Planning Scheme Local Provision to include reference to the *Mildura Rural City Council Stormwater Quality Management Plan*. Specific amendments includes updates to: **Clause 21.01-2 Settlement** Amend to encourage Water Sensitive Urban Design and best practice stormwater management for new development. **Clause 21.04-4 Environment** Amend to ensure that best practice stormwater management is identified as a strategy for achieving Objectives within this clause. The Referred Documents lists should be updated to include the *Mildura Rural City Council Stormwater Quality Management Plan*. **Clause 21.04-7 Infrastructure** Amend overview to include reference to best practice stormwater management objectives and encourage the use of Water Sensitive Urban Design principles for new drainage infrastructure. The Referred Documents lists should be updated to include the *Mildura Rural City Council Stormwater Quality Management Plan.* Amendments to the Mildura Planning Scheme should be made as opportunities arise during scheduled revision. In the meantime, Council can use the State Planning Policy Framework Clause 15.01 to guide decision making.	Very high
B2.3	Council should identify appropriate Water Sensitive Urban Design principles suitable for the Mildura region that can be effectively incorporated into new development and upgrades of existing infrastructure. These principles should be disseminated to land developers for incorporation into designs for new urban development (also see **Action B4.3** & **A8.3**).	High
	Strategy B3 – Planning Referrals and Approvals Process *To ensure an effective referrals and approvals process for planning permit applications for new development.*	
B3.1	Council should improve the management of the referrals process by assigning a dedicated Council Officer to manage the referrals process.	Very high
B3.2	Council should coordinate with External Referral Authorities to ensure all authorities are familiar with the approvals and referrals process contained within Section 55 of the *Planning and Environment Act 1987* and Clause 66 of the Mildura Planning Scheme. It is important that referral authorities are familiar with the requirements of the act to ensure consistency in the referrals and approvals process (also see **Action A8.1**).	Very high
B3.3	Council should ensure that all proposals where there is likely to be an increase in stormwater discharge are referred internally to an appropriate Officer for assessment of potential environmental impacts and to ensure the best practice stormwater management objectives are incorporated into the development proposal. The most appropriate internal Officer would be the Environmental and Stormwater Management Officer (also see **Action A8.2**).	Very high
B3.4	Council should establish a protocol for pre planning application meetings between applicants, Council and referral authorities to ensure that proponents fully understand the application requirements and are familiar with the best practice stormwater management requirements outlined in the stormwater management plan (also see **Action A8.4**).	Very high

Table 6.1 Cont/..

Action	Description	Priority
Strategy B4 - Incorporate Best Practice Stormwater Management in land use planning and urban design *To ensure best practice stormwater management and water sensitive urban design is incorporated into all stages of urban development including planning application, design and construction stages and to encourage improved water use efficiencies and stormwater management within the broader community.*		
B4.1	Council should ensure that conditions relating to sediment and litter control on development and construction sites are appropriate for the Mildura region.	Very high
B4.2	Council should ensure that techniques for sediment control, stormwater treatment and water sensitive design are readily available to the land development industry. Awareness of the *Best Practice Environmental Management Guidelines*, the *Mildura Rural City Council Stormwater Quality Management Plan* and other relevant guidelines could be raised through the preparation of a brochure and information and training sessions for the land development industry. Reference to techniques for best practice stormwater management should also be incorporated into the Council's *Subdivision Development Guidelines*.	Very high
B4.3	Council should require that Water Sensitive Urban Design principles appropriate for the region (**Action B2.3**) are incorporated into all new development proposal prior to approval. Council staff and referral authorities can then assess proposals based on their proposed water sensitive design principles.	Very high
B4.4	Council should ensure that new development proposals and changes in land use are sympathetic to the natural and cultural environment and that any increase in stormwater runoff is minimised and treated using wetlands, sediment traps and local detention measures prior to discharge to receiving environments.	Very high
B4.5	Council should encourage the use of household rainwater tanks for watering gardens and investigate the feasibility of household grey water recycling for toilet flushing (**Action A6.1**).	High
Strategy B5 – Incorporate Best Practice Stormwater Management in Council's day-to-day operations and management *To demonstrate Council's commitment to stormwater management by incorporating best practice management into Council's day to day operations and management*		
B5.1	Council should formalise and document the process for routine inspection and maintenance of the stormwater drainage system. This documentation should assess asset condition, identify known problem areas and establish a regular maintenance program. It should also incorporate **Actions A4.3** & **A4.4**.	Very high
B5.2	Council should amend the regular practices of its operations where these can contribute to improved stormwater management as identified in **Actions A18.1** & **A18.2**.	Very high
B5.3	Council should avail itself of relevant literature and technical guidelines relevant to stormwater management and subscribe to relevant industry associations eg the Stormwater Industry Association Inc. (phone: 1800 761 777) who produce regular newsletters with information about new initiatives, techniques, seminars etc relevant to urban stormwater management.	Very high
B5.4	Council should establish a commitment to long term monitoring of the effectiveness of stormwater initiatives implemented under this plan (see **Action B1.7**).	Very high
Strategy B6 – Education and Training *To implement effective education and training programs for Council staff and facilitate training for external agencies and stakeholders to improve stormwater management in the Mildura region*		
B6.1	Council should implement training and education programs for Council staff and contractors to improve awareness of stormwater management issues, roles and responsibilities as identified in **Action A5.1**.	Very high
B6.2	Council should facilitate training and education programs for Council staff and emergency services involved in emergency response to highlight requirements for the protection of stormwater quality and receiving environments under actions within the Emergency Response Plan (also see **Action A1.2**).	High
B6.3	Council should facilitate training sessions for Council staff and referral authorities involved in the planning approvals and referrals process to ensure all parties are conversant with the requirements of the Planning and Environment Act 1987 (also see **Action B3.3**).	
B6.4	Council should facilitate workshops and information sessions for the Land and building development industry to inform them of Council's requirements for best practice stormwater management and highlight the options available to developers to satisfy Council's stormwater management objectives (Links with actions identified in **Strategies A8**, **B3** & **B4**).	Very high

Table 6.1 Cont/..

Action	Description	Priority
Strategy B7 – Regulation and Enforcement *To make effective use of existing regulations and establish new Local Laws to support Council in their efforts aimed at reducing the impacts of stormwater runoff and the protection of Council assets and the local environment.*		
B7.1	Council should ensure sufficient resources are available to adequately inspect and enforce planning permit conditions on development sites. This requires that suitably qualified technical staff be available for regular inspections of development sites during the maintenance period.	Very high
B7.2	Council should assess the capacity to implement new Local Laws, particularly with regard to resources for enforcement and powers of delegation.	High
B7.3	If capacity to implement new Local Laws exists then Council should expand Environmental Local Law No. 3 to include a new Local Law controlling sediment and litter on building construction sites. The Department of Infrastructure has prepared a Code of Practice *Protection of Council Assets and Control of Building Sites* to assist Council with the development and enforcement of relevant Local Laws aimed at the protection of local environments.	High
Strategy B8 – Coordinate Best Practice Management with other Authorities and Groups *To ensure Council effectively communicates and coordinates with other authorities, stakeholders and community groups on a regional and State level and to ensure Council is kept up to date on new initiatives and developments in urban stormwater management.*		
B8.1	Council should coordinate with other Authorities such as the EPA, NRE, Mallee Catchment Management Authority and regional water authorities to ensure effective stormwater management across the region.	Very high
B8.2	The Council Stormwater Management Officer should participate in broader regional and State based forums on stormwater management to ensure the Mildura Rural City Council remains up to date on relevant stormwater initiatives across the State.	Very high
B8.3	Council should coordinate with other Councils and State agencies to identify opportunities for improved stormwater management and ensure a more coordinated outcome for State based projects.	High
B8.4	Council should liase with community groups who have interest in stormwater and environmental management and ensure they are consulted at appropriate times during the implementation of the stormwater management plan.	High

9.2 Best practice guidelines and documents

A range of best practice guidelines and documents are available to the Council, other stakeholders and people involved in the development and construction industry to aid in best practice management. There are also organisations that provide regular information on stormwater management issues, seminars and technological advances. The following list provides details of these information sources.

Guidelines

DOI (2000). A code of practice for protection of Council assets and control of building sites. Department of Infrastructure (Available at www.doi.vic.gov.au).

EPA (1991). Construction techniques for sediment pollution control. Environment Protection Authority Publication no. 275 (Available from www.epa.vic.gov.au)

EPA (1998). Development approvals in sewered and unsewered areas. Environment Protection Authority Publication no. 629 (Available from www.epa.vic.gov.au)

EPA (2001). Land capability assessment for onsite domestic wastewater management. Environment Protection Authority Publication no. 746 (Available from www.epa.vic.gov.au).

Lawrence, I. and Breen, P. (1998). Design guidelines: Stormwater pollution control ponds and wetlands. Cooperative Research Centre for Freshwater Ecology (Available from www.freshwater.canberra.edu.au).

Mitchell, G., Mein, R., and McMahon, T. (1999). The reuse potential of urban stormwater and wastewater. Cooperative Research Centre for Catchment Hydrology Industry Report 99/14 (Available from www.catchment.crc.org.au).

Victorian Stormwater Committee (1999). Urban stormwater: Best practice environmental management guidelines. CSIRO Publishing: Melbourne.

Walker, T. and Wong, T. (1999). Effectiveness of street sweeping for stormwater pollution control. Cooperative Research Centre for Catchment Hydrology Technical Report 99/8 (Available from www.catchment.crc.org.au).

Wong, T., Breen, P., Somes, N. and Lloyd, S. (1998). Managing urban stormwater using constructed wetlands. Cooperative Research Centre for Catchment Hydrology Industry Report 98/7 (Available from www.catchment.crc.org.au).

Wong, T., Breen, P. and Lloyd, S. (2000). Water senstive urban road design – design options for improving stormwater quality of road runoff. Cooperative Research Centre for Catchment Hydrology Technical Report 00/1 (Available from www.catchment.crc.org.au).

Victorian State Government (1995). Victoria's litter reduction strategy (Available from www.epa.vic.gov.au).

Useful Internet Pages

CRC for Catchment Hydrology www.catchment.crc.org.au
Department of Infrastructure www.doi.vic.gov.au
Victorian Environment Protection Authority www.epa.vic.gov.au
NSW Environment Protection Authority www.epa.nsw.gov.au

Associations

Stormwater Industry Association Inc. 1800 761 777
(director@stormwater.industry.com)

10. Implementation and review

The effectiveness of the stormwater management plan is dependent upon the Council's ability to implement the recommendations of the plan. The implementation framework provides Council with guidance on how to resource and coordinate the implementation of the stormwater management plan. The following provides a framework for assisting Council with successful implementation of the stormwater management plan.

10.1 Responsibility for Implementation

Implementation of the stormwater management plan should follow the recommended actions identified in the plan. In order to effectively coordinate the implementation of these actions Council must assign a staff member with responsibility for coordinating implementation. In Mildura, the coordinator's role could be assigned to the new position of Environment and Stormwater Management Officer (**Action B1.3**).

To assist the Coordinator, an Implementation Committee should also be established. This committee would ideally consist of representative from all sections of Council relevant to stormwater management including, planning, engineering and infrastructure, parks and gardens, waste management services and health services. Relevant personnel from outside agencies, such as the Mallee CMA and the EPA could also be included in the Implementation Committee. The Implementation Committees role would be to oversee and coordinate the progressive implementation of the stormwater management plan.

It is also recommended that the Reference Group and Project Working Group established for the development of this stormwater management plan be combined and used to act in a review role during the implementation of the plan.

10.2 Implementation process

A suggested time frame for implementation has been provided for each of the actions identified in the Reactive Management Strategies. Typically, low cost actions have been recommended for immediate implementation while higher costs actions are recommended for implementation over a longer period of time depending upon funding availability.

The implementation of actions can be flexible depending upon funding availability, however it is recommended that a schedule for implementation be established to assist in determining funding requirements over the implementation stages of the plan. The implementation schedule should be dynamic and updated as works are completed, additional works are required, or as new issues arise. The implementation schedule should be reviewed on an annual basis, prior to the preparation of Council's Works Programs. This is to identify progress of works to date, the works to be implemented in the following year and the funding and budgetary requirements for these works.

10.3 Monitoring and review

The effectiveness of the stormwater management plan should be measured with a comprehensive monitoring and review program (Table 10.1). There are two levels to this program:

1) Review of the implementation of actions and progress against the plan objectives; and
2) Monitoring of the effectiveness of actions at improving the quality of stormwater runoff and protection and enhancement of the values of receiving environments.

The stormwater management plan should be reviewed and revised regularly to ensure that the objectives, issues and options identified within the Plan are still relevant and provide the necessary information for Council's improvement program.

The Plan should be updated as required, but within 3 years from completion or the last revision (with the exception of the Implementation Schedule which is updated annually, as discussed above).

When reviewing/revising the stormwater management plan, the following aspects should be considered:

- Results from any water quality monitoring programs and environmental studies;
- The effectiveness of options implemented during the previous years;
- Whether short term management objectives have been satisfied;
- Any additional objectives that are required;
- Improved understanding of stormwater issues and impacts within local catchments;
- Any issues not previously addressed that need to be considered; and
- Whether additional management options need to be developed.

The effectiveness-monitoring program should be a comprehensive program for monitoring water quality and other parameters in the region that are impacted upon by stormwater runoff (See Section 8.2). Council should consult with the EPA, the Mallee CMA and other water quality experts to ensure a suitable and effective monitoring program is established. The program should consist of routine water quality monitoring and targeted programs aimed at problem areas or at determining if specific actions are effective at reducing the impacts of stormwater runoff. Detailed reporting should be conducted to inform the community and other stakeholders of the effectiveness of the actions in the stormwater management plan at improving water quality. Initially, reporting could be conducted 6-monthly as the plan is implemented and then annually once actions have been implemented, to report on progress and effectiveness of actions at addressing stormwater issues.

Results from the water quality monitoring program should feed-back into the review of the stormwater management plan. For example, an examination of the litter collected in litter traps could help Council in identifying the source of such litter eg fast food outlets, which can then be used to develop targeted education programs in particular areas.

■ **Table 10.1. Review and Monitoring schedule for implementation of the Mildura Rural City Council Urban Stormwater Quality Management Plan (3-year rolling schedule).**

Year	Year 1				Year 2				Year 3			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4
Implementation Committee meeting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Water quality monitoring	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Review/revise Implementation Schedule & prepare works plan		✓				✓				✓		
Revise Stormwater Management Plan												✓

10.4 Funding options

The full implementation of all actions identified in the stormwater management plan requires a significant funding commitment. Many of the actions may be implemented at a cost much reduced from that indicated through modification to current Council procedures and the use of in-house resources, for example in the development of education material and initiation of workshops and information sessions. However, there is still a need to ensure stormwater management actions are identified in Council's annual budget and that funding opportunities outside Council are also identified.

Actions identified in the stormwater management plan should be incorporated into Council's capital works program and budget. Separate funding lines could be established for existing and new works. The capital works program and budget should be reviewed and revised where current projects can be modified to incorporate actions identified in the plan. For example, best practice management techniques should be incorporated into any current drainage or road upgrades. Cost sharing initiatives should be identified and established with other agencies. For example, Council and the Mallee CMA could jointly fund community education programs.

There is also a range of funding options outside of Council's own budget. The Victorian Government through the Victorian Stormwater Action Program (VSAP) is providing grants to local Councils for the implementation of actions identified in stormwater management plans. This stormwater management plan has been prepared according to VSAP guidelines such that funding can be requested for actions identified in this plan. Funding under the VSAP grants program is available for actions such as education programs, structural treatment measures, assistance with planning scheme amendments, feasibility studies and monitoring programs and upto 50% of the eligible cost can be provided. Funding is not available for providing salaries to Council staff, however salaries are considered an 'in-kind' contribution.

In the Murray-Darling Basin, funding under the Natural Heritage Trust - Murray Darling 2001 Program is available for on-ground works that will result in a reduction of nutrients, salt and sediment inputs to rivers and wetlands. However, this funding program is due to finish at the end of 2001 and a new program has not yet been established. Funding is also available through organisations such as EcoRecycle for actions relating to waste management, recycling and education programs.

New funding opportunities arise from time to time and the designated Stormwater Coordinator should ensure they are familiar with all funding options.

11. Summary

The *Management Plan for the Improvement of Urban Stormwater Quality for the Mildura Rural City Council* provides Council with the strategic basis for improved stormwater management and hence improved environmental condition for waterways and wetlands in the Mildura area. The plan has been developed according the requirements of the Victorian Stormwater Committee and in close consultation with the Council and stakeholders through regular meetings and workshops. This has ensured that the actions identified in the plan are considered by the Council and stakeholders to be the most relevant for addressing urban stormwater issues in the Mildura region. Adherence to the requirements of the Victorian Stormwater Committee also ensures that the plan provides the appropriate support necessary for successful funding for actions identified in the plan.

The plan identifies a mix of reactive and management strategies that once established will improve the quality of urban stormwater runoff and protect and enhance the values of waterways and wetlands in the Mildura region. Overall benefits will include improved water quality, reduced risk of algal blooms, enhanced recreational opportunities and water supply protection.

The success of initiatives identified in the plan is dependent on Council's commitment to establish the recommended framework for implementation. This includes the appointment of a suitably qualified Environmental and Stormwater Management Officer to coordinate the implementation of the plan, identify internal and external funding opportunities, and coordinate the establishment of a rigorous monitoring and review program. The ultimate success of the plan will be evident when stormwater management is fully integrated into Council's management framework.

12. References

AHC (2001). Register of the National Estate Database. Australian Heritage Commission.

Andrew C. Ward & Associates (1986). Mallee Area Review Study of Historic Sites. Unpublished report to the Land Conservation Council.

Bardwell, S. (1980). Interim Report on the History of Hattah-Kulkyne National Park, Murray Kulkyne Park. National Parks Service.

Bluml, M. (1992). Sunraysia Salinity Management Plan Environmental Report. Department of Conservation and Environment.

CMPS&F (1994a). Irymple stormwater disposal system - rising main and basin investigation. Report prepared for Shire of Mildura.

CMPS&F (1994b). Red Cliffs township drainage future disposal strategy. Report prepared for the Shire of Mildura.

CMPS&F (1995). Calder Highway Sandilong Avenue to San Mateo Avenue Drainage Strategy Study (inlcuding Addendum A). Report prepared for Vic Roads.

Crabb, P. (1997). Murray Darling Basin Resources. Murray Darling Basin Commission, Canberra.

DCNR. (1993). Kings Billabong Wildlife Reserve Proposed Management Plan. First Draft. Department of Conservation and Natural Resources, Mildura.

EA (2001). A Directory of Important Wetlands in Australia. Australian Nature Conservation Agency.

ECOS (2001). Environmental values of the Wargan Basins, Lake Ranfurly (East and West) and Lake Hawthorn. Report prepared by ECOS Environmental Consulting for Goulburn-Murray Water.

Edmonds, V. (1994). An Archaeological Survey of Kings Billabong Wildlife Reserve. Report to AAV.

Edmonds, V. (1997). Bowen Park Aboriginal Shell Midden, Salvage Report. Report to Sunraysia Environmental, Mildura.

Edmonds, V. (1998). Berri-Mildura Pipeline (Victorian Section) Aboriginal Cultural Heritage. Report prepared for Ecos Consulting and Boral Energy.

Edmonds, V. (1999). Desktop Heritage assessment SANI Proposed Corridors in NSW and Victoria. Report prepared for Sinclair Knight Merz, Sydney.

Egis Consulting (1999). Mallee Region Surface Water Quality Inception Report. Report prepared for the Mallee Catchment Management Authority.

Kenderdine, S. (1994). Historic Shipping on the Murray River: A guide to the Terrestrial and Submerged Archaeological Resources in New South Wales and Victoria. Department of Planning, NSW, Department of Planning and Development, Victoria & Murray Darling Basin Commission.

LCC (1987). Report on the Mallee Area Review. Land Conservation Council, Melbourne.

MRCC (2001). Sunraysia drainage strategy current situation report. Report prepared by Ron Dudley for the Mildura City Council.

Penney, J. (1993). Heritage Sites in the Southern Murray Basin: a Survey Report for the Southern Murray Basin Archaeological Project. Unpublished report to Murray Darling Basin Commission.

Shirley, M., N. Souter, and L. Lloyd. (1997). Management plan for the Cardross Lakes system and the associated fish assemblage. Report prepared by Water Ecoscience P/L for the Cardross Lakes Task Group.

SKM. (1996). Kings Billabong Historical Seepage and Evaporation Loss Estimates. Report for First Mildura Irrigation Trust. Sinclair Knight Merz, Melbourne.

SKM (1998a). Etiwanda Wetland: Draft Concept Design. Report prepared for the Mildura Rural City Council.

SKM (1998b). Sunraysia Region Evaporation Disposal Basin Risk Assessment. S154 Sunraysia Technical Support: Evaporation Basin Risk Assessment. Appendix A. Report for Sunraysia Salinity Management Plan Implementation Group. Sinclair Knight Merz, Melbourne.

SKM (2001). Sunraysia Drainage Strategy and Urban Stormwater Management Plan. Issues Paper no. 1 - Background. Report prepared by Sinclair Knight Merz for the Mildura Rural City Council.

SMEC and LEC (2000). Water Quality Management Plan: Investigation Report. Report prepared by the Snowy Mountains Engineering Corporation and Lloyd Environmental Consultants for the Mallee Catchment Management Authority.

TGM (2001a). Calder sub-basin stormwater collection and storage strategy. Report prepared for Mildura Rural City Council.

TGM (2001b). Elizabeth Street-15th Street Drainage Investigation. Report prepared by Thoms Gibcus McGrath for the Mildura Rural City Council.

Victorian Government (1988). State Environment Protection Policy (The Waters of Victoria). Policy No. S122.

Victorian Stormwater Committee (1999). Urban stormwater: best practice environmental management guidelines. CSIRO Publishing, Melbourne.

Appendix A Threatened species lists

Key for determination of conservation status in Victoria
Ins – insuficient information
CEn – Critically endangered
End – Endangered
Vul – Vulnerable
LR – Lower risk near threatened
FFG – Listed under the Victorian *Flora and Fauna Guarantee Act 1988*
C – Listed under the China Australia Migratory Bird Agreement (CAMBA)
J – Listed under the Japan Australia Migratory Bird Agreement (JAMBA)

Threatened fauna and flora species recorded at Wargan Basins (Source :ECOS 2001)

Common name	Scientific name	Conservation status[a]
FAUNA		
Brown Quail	*Coturniz ypsilophora*	Ins
Baillon's Crake	*Porzana pusilla*	Vul, FFG
Pied Cormorant	*Phalacrocax varius*	LR
Wiskered Tern	*Chilidonias hybridus*	LR
Caspian Tern	*Hydroprogne caspia*	C
Black-tailed Godwit	*Limosa limosa*	CJ
Common Sandpiper	*Actitis hypoleucos*	CJ
Common Greenshank	*Tringa nebularia*	CJ
Curlew Sandpiper	*Calidris ferruginea*	CJ
Marsh Sandpiper	*Tringa stagnatilis*	CJ
Red-necked Stint	*Calidris ruficollis*	CJ
Sharp-tailed Sandpiper	*Calidrus acuminata*	CJ
Brolga	*Grus rubicunda*	Vul, FFG
Glossy Ibis	*Plegadis falcinellus*	Vul, C
Little Egret	*Egretta garzetta*	CEn, FFG
Great Egret	*Ardea alba*	End, FFG, CJ
Australasian Shoveler	*Anas rhynochotis*	Vul
Freckled Duck	*Stictonetta neavosa*	End, FFG
Hardhead	*Aythya australis*	Vul
Blue-billed Duck	*Oxyura australis*	Vul, FFG
Musked Duck	*Biziura lobata*	Vul
Black Falcon	*Falco subniger*	End
Rainbow Bee-eater	*Merops ornatus*	J
FLORA		
Long tails	*Ptilotus polystachyua* var. *polystachyus*	End
Pearl Bluebush	*Maireana sedifolia*	r
Buloke Mistletoe	*Amyema linophylla* ssp. *orientale*	v
Twiggy Sida	*Sida intricata*	v
Wait-a-while	*Acacia colletioides*	r
Nealie	*Acacia loderi*	v
Myall	*Acacia melvillei*	v
Umbrella Wattle	*Acacia oswaldii*	v
Silver Needlewood	*Hakea leucopetera* ssp. *Leucoptera*	v
Hooked Needlewood	*Hakea tephrosperma*	v
Smooth-flower Tobacco	*Nicotiana goodspeedii*	r

Threatened fauna species recorded at Lake Ranfurly (Source: ECOS 2001).

Common Name	Species Name	Status
FAUNA		
Pied Cormorant	*Phalacrocorax*	LR
Whiskeres Tern	*Childonias hybridus*	LR
Gull-billed Tern	*Sterna nilotica*	End FFG listed
Caspian Tern	*Sterna caspia*	Vul, FFG listed, CJ
Ruddy Turnstone	*Arenaria interpres*	CJ
Black-tailed Godwit	*Limosa limosa*	CJ
Bar-tailed Godwit	*Limosa lapponica*	CJ
Common Greenshank	*Tringa nebularia*	CJ
Marsh Sandpiper	*Tringa stagnatillis*	CJ
Curlew Sandpiper	*Calidris ferruginea*	CJ
Red-necked Stint	*Calidris ruficollis*	CJ
Sharp-tailed Sandpiper	*Calidris acuminata*	CJ
Red Knot	*Calidris canutus*	CJ
Great Knot	*Calidris tenuirostris*	CJ
Glossy Ibis	*Plegadis falcinellus*	Vul, CJ
Royal Spoonbill	*Platalea regia*	Vul
Little Egret	*Egretta garzetta*	CEn, FFG listed
Great Egret	*Ardea alba*	End, FFG listed, CJ
Australasian Shoveier	*Anas rhynchotis*	Vul
Freckled Duck	*Stictonetta naevosa*	End, FFG listed
Hardhead	*Aythya australis*	Vul
Blue-billed Duck	*Oxyura australis*	Vul, FFG listed
White-bellied Sea-eagle	*Haliaeetus leucogaster*	End FFG listed C
Black Falcon	*Falco subniger*	End
Red-backed Kingfisher	*Taodiramphus pyrrhopygia*	Vul
Rainbow Bee-eater	*Merops ornatus*	J

Threatened flora and fauna species recorded at Lake Hawthorn (Source: ECOS 2001).

Common Name	Species Name	Status
FLORA		
Mealy Saltbush	*Atriplex pseudocampanulata*	R
Twin-flower Saltbush	*Dissocarpus biflorus* var. *viflorus*	R
Nealie	Acacia loderi	V
FAUNA		
Pied Cormorant	*Phalacrocorax*	LR
Whiskered Tern	*Childonias hybridus*	LR
Gull-billed Tern	*Sterna nilotica*	End FFG listed
Caspian Tern	*Sterna caspia*	Vul, FFG listed, CJ
Ruddy Turnstone	*Arenaria interpres*	CJ
Balck-tailed Godwit	*Limosa limosa*	CJ
Bar-tailed Godwit	*Limosa lapponica*	CJ
Common Greenshank	*Tringa nebularia*	CJ
Marsh Sandpiper	*Tringa stagnatillis*	CJ
Curlew Sandpiper	*Calidris ferruginea*	CJ
Red-necked Stint	*Calidris ruficollis*	CJ
Sharp-tailed Sandpiper	*Calidris acuminata*	CJ
Red Knot	*Calidris canutus*	CJ
Great Knot	*Calidris tenuirostris*	CJ
Glossy Ibis	*Plegadis falcinellus*	Vul,C
Royal Spoonbill	*Platalea regia*	Vul
Little Egret	*Egretta garzetta*	CEn, FFG listed
Intermediate Egret	*Ardea intermedia*	CEN, FFG listed
Great Egret	*Ardea alba*	End, FFG listed, CJ
Australasian Shoveier	*Anas rhynchotis*	Vul
Freckled Duck	*Stictonetta naevosa*	End, FFG listed
Hardhead	*Aythya australis*	Vul
Blue-billed Duck	*Oxyura australis*	Vul, FFG listed
White-bellied Sea-eagle	*Haliaeetus leucogaster*	End FFG listed C
Black Falcon	*Falco subniger*	End
Red-backed Kingfisher	*Taodiramphus pyrrhopygia*	Vul
Rainbow Bee-eater	*Merops ornatus*	J
Flat-headed Galaxia	*Galaxias rostratus*	Ins
Murray Hardyhead	*Craterocephalus fluviatilis*	End, FFG listed

Common Name	Species Name	Status
Unspecked Hardyhead	*Craterocephalus stercusmuscarum fluvus*	FFG listed
Golden Perch	*Macquaria ambigua*	Vul

Threatened fauna species recorded at Cardross Lakes (Source: Shirley et al 1997).

Common Name	Species Name	Status
Freshwater Catfish	*Tandanus tandanus*	Vul
Golden Perch	*Macquaria ambigua*	Vul
Murray Cod	*Maccullochella peeli peeli*	Vul, FFG
Murray Hardyhead	*Craterocephalus fluviatilis*	End, FFG listed
Southern Purple-spotted Gudgeon	*Morgunda adspersa*	CEn, FFG

Appendix B Detailed values assessment

Receiving Environment	Locations	Value type	Characteristics	Current ranking	Potential uses / values to be enhanced or protected	Potential ranking
Murray River above Lock 11	Mildura, Red Cliffs	Environmental	• High quality habitat • Significant River Red Gum forests • Rare and threatened flora and fauna • Very high scenic value • Register of the National Estate as a natural place (Murray River Forest, Red Cliffs) • Kings Billabong Wildlife Reserve – Wetland of National Importance (see Kings Billabong)	Very high	• Protect current environmental values • Enhance values by improving the quality of stormwater and drainage water discharged to river • Promote and encourage appreciation of environmental values	Very high
		Cultural	• Long record of association with Indigenous people • Non-indigenous connections from the early 1800s • National Estate listings (Lock and Weir no. 11)	Very high	• Protect current cultural values • Ensure archaeological and heritage sites are protected • Promote and encourage appreciation of cultural significance	Very high
		Amenity	• Significant for regional tourism • Very high visual amenity • High recreational opportunities: bird watching, camping, fishing, boating, swimming • Nature conservation and education	Very high	• Encourage environmentally sensitive recreational activities	Very high
		Economic	• Irrigation, stock, domestic and industrial water supply to Mallee region	Very high	• Protect quality of water supply by reducing inputs of salt and nutrients	Very high
		Drainage	• Provides drainage services from irrigation areas • Volume of Murray River water is likely to provide some dilution of stormwater pollutants	High	• Reduce reliance on river as an outfall for nutrient rich and saline drainage water and stormwater	High

Receiving Environment	Locations	Value type	Characteristics	Current ranking	Potential uses / values to be enhanced or protected	Potential ranking
Murray River below Lock 11	Mildura, Merbein, Yelta	Environmental	• High quality habitat • Significant River Red Gum forests • Rare and threatened flora and fauna • Very high scenic value	Very high	• Protect current environmental values • Enhance values by improving the quality of stormwater and drainage water discharged to river • Promote and encourage appreciation of environmental values	Very high
		Cultural	• Long record of association with indigenous people. • Non-indigenous connections from the early 1800s	Very high	• Protect current cultural values • Ensure archaeological and heritage sites are protected • Promote and encourage appreciation of cultural significance	Very high
		Amenity	• Significant for regional tourism • Very high visual amenity • High recreational opportunities: bird watching, camping, fishing, boating, swimming • Nature conservation and education	Very high	• Encourage environmentally sensitive recreational activities	Very high
		Economic	• Irrigation, stock and domestic water supply to Mallee region	Very high	• Protect quality of water supply by reducing inputs of salt and nutrients	Very high
		Drainage	• Provides drainage services from irrigation areas • Volume of Murray River water is likely to provide some dilution of stormwater pollutants	High	• Reduce reliance on river as an outfall for nutrient rich and saline drainage water and stormwater	High

Receiving Environment	Locations	Value type	Characteristics	Current ranking	Potential uses / values to be enhanced or protected	Potential ranking
Kings Billabong	Mildura, Red Cliffs	Environmental	• High quality habitat • Significant River Red Gum forests • Rare and threatened flora and fauna • High scenic value • Wetland of National Importance • Register of the National Estate as a Natural place	Very high	• Protect current environmental values • Enhance values by improving the quality of surface and drainage water discharged to wetland • Promote and encourage appreciation of environmental values • Potential to restore some seasonality to water level but must be balanced by need to prevent groundwater seepage to wetland	Very high
		Cultural	• Long record of association with indigenous people • 24 significant archaeological sites • Significant non-indigenous heritage sites including sites listed on the National Estate (Psyche Bend Pump House and Billabong Pumps)	Very high	• Ensure archaeological and heritage sites are protected • Promote and encourage appreciation of cultural significance	Very high
		Amenity	• High active and passive recreational amenity • Primary recreational contact • High visual amenity • Bird watching, camping, fishing, boating • Nature conservation • High visual amenity, including for rural residential development along western side	Very high	• Encourage environmentally sensitive recreational activities • Protect visual amenity	Very high
		Economic	• Transfer lake for FMIT irrigation supply • Re-use opportunities	High	• Protect quality of water supply by reducing inputs of salt and nutrients • Potential to reduce reliance on Kings Billabong for water supply by bypassing with pipes for supply system	Moderate
		Drainage	• Receives some irrigation drainage water and rural surface runoff which is reused via irrigation supply system	Moderate	• There is potential for more drainage water to enter Kings Billabong from rural residential development. This needs to be tightly controlled	Moderate

Table 3.3 Cont\..

Receiving Environment	Locations	Value type	Characteristics	Ranking	Potential values	Potential ranking
Psyche Bend lagoon	Red Cliffs	Environmental	• Highly degraded by inputs of saline groundwater • Provides some habitat for avifauna • Poor water quality and potential for algal blooms	Low	• Limited opportunity to enhance environmental values	Low
		Cultural	• Possible location of archaeological sites given Riverine Landform	Moderate	• Identify sites if management changes	Moderate
		Amenity	• Limited recreational opportunities • Low visual amenity due to low water levels and dead vegetation • Some educational values to demonstrate the impacts of salinity	Low	• Promote educational values	Low
		Economic	• Not suitable for water supply	Low	• No opportunity to enhance water supply values	Low
		Drainage	• Receives some saline FMIT drainage water that would otherwise negatively impact on the Murray River • Managed to prevent saline groundwater from entering Murray River and Kings Billabong	Very high	• Continue to manage in a way that protects Murray River and Kings Billabong from saline groundwater inputs	Very high
Basin 12	Red Cliffs	Environmental	• Extensive reed-bed habitat for avifauna	High	• Investigate whether water level is pressure on groundwater table	High
		Cultural	• Possible location of archaeological site given Riverine landform	Moderate	• Identify sites if management changes	Moderate
		Amenity	• Limited recreational opportunities • Provides some visual amenity to rural residential development on western side	Moderate	• New development may take advantage of visual amenity	Moderate
		Economic	• Limited use as water supply by several private diverters	Low	• Decreased inflows likely to reduce value further	Low
		Drainage	• Main irrigation and stormwater drainage basin for Red Cliffs • Extensive reed-beds provide sediment and nutrient removal prior to discharge to Murray River	Very high	• Decreases in drainage flows as a result of changes in irrigation practices may reduce reliance on Basin 12	High
Cardross lakes	Red Cliffs	Environmental	• Rare and threatened fish including Purple-spotted Gudgeon • Reed vegetation provides habitat for birds	Very high	• Manage to protect and enhance environmental value for native fish community by increasing supply of freshwater	Very high
		Cultural	• Limited potential significance given landform	Low	• Identify sites if management changes	Low
		Amenity	• Provides some recreational opportunities for boating, fishing, bird watching etc but not popular	Low	• Potential to enhance educational and nature conservation values	High
		Economic	• Receives drainage water but is becoming less important as a result of water use efficiencies •	Low	• Potential as transfer basin to supply water to new irrigation development (eg Deakin Development)	High
		Drainage	• Receives drainage water but is becoming less important as a result of water use efficiencies	Moderate	• Potential for current drainage infrastructure to be used to alleviate surface flooding during storm events around Red Cliffs • Excess capacity could be used for drainage from new developments	High

Receiving Environment	Locations	Value type	Characteristics	Current ranking	Potential uses / values to be enhanced or protected	Potential ranking
Koorlong Basin	Koorlong	Environmental	• Hypersaline • Provides limited habitat for waterbirds • Degraded vegetation	Low	• Unchanged	Low
		Cultural	• Some evidence of archaeological sites	Moderate	• Unchanged	Moderate
		Amenity	• Limited recreational opportunities	Low	• Unchanged	Low
		Economic	• Not suitable for water supply or re-use	Low	• Unchanged	Low
		Stormwater / drainage	• Main terminal basin for FMIT drainage	Very high	• Unchanged	Very high
Lamberts Swamp		Environmental	• Hypersaline swamp • Some habitat value for waterbirds	Low	• Potential to improve surrounding habitat by revegetation	Moderate
		Cultural	• Limited potential significance given landform	Low	• Unchanged	Low
		Amenity	• Limited recreational opportunities • Low amenity value, surrounded by cleared areas	Low	• Unchanged	Low
		Economic	• Not suitable for water supply or re-use	Low	• Unchanged	Low
		Drainage	• Drainage basin for local irrigation runoff	High	• May be bypassed in the future but potential to use swamp for generating EC credits	Very high
Lake Ranfurly East	Mildura	Environmental	• Rare and threatened avifauna • Possible rare and threatened saltbush flora • Wetland of national importance • Water quality generally poor, however high salinity supports food resources for birds	Very high	• Protect current habitat for avifauna • Investigate presence of rare flora	Very high
		Cultural	• Burial site located on lake shore and likely to be other significant sites • Urban development and agriculture have degraded cultural values	High	• Survey for other archaeological sites • Protect current known site	Very high
		Amenity	• Generally degraded around lake • Popular for bird watching	High	• Potential for revegetation and improvement of visual amenity • Potential for high visual amenity from new housing development	Very high
		Economic	• Not suitable for water supply or re-use	Low	• Unchanged	Low
		Stormwater / drainage	• Drainage basin for saline groundwater and stormwater • Prevents saline groundwater entering Murray River via groundwater interception schemes	Very high	• Any changes to current operation of interception scheme that would threaten the environmental values could trigger EPBC Act	Very high

Table 3.3 Comt\..

Receiving Environment	Locations	Value type	Characteristics	Ranking	Potential values	Potential ranking
Lake Ranfurly West	Mildura	Environmental	• Hypersaline • Habitat for avifauna (see Lake Ranfurly East	Very high	• Protect current habitat for avifauna • Investigate presence of rare flora	Very high
		Cultural	• See Lake Ranfurly East	High	• Survey for other archaeological sites • Protect current known site	Very high
		Amenity	• Degraded around lake margins • Limited options for recreational activities	Low	• Limited potential for revegetation and amenity improvement • Promote educational values	Moderate
		Economic	• See Lake Ranfurly East	Low	• Unchanged	Low
		Drainage	• See Lake Ranfurly East	Very high	• Any changes to current operation of interception scheme that would threaten the environmental values could trigger EPBC Act	Very high
Riffle *Butts Swamp*	Mildura	Environmental	• Small evaporation and transfer basin • Limited environmental value although may provide some bird habitat at times • Degraded by extension of Ontario Avenue	Moderate	• Potential for improved value if revegetated	High
		Cultural	• Urban development and agriculture likely to have degraded cultural values	Low	• Investigate possible cultural sites	Low
		Amenity	• Limited visual amenity • No recreational oportunites	Low	• Potential to provide visual amenity for new residential development and potential for revegetation and nature conservation in an urban area	High
		Economic	• Not suitable for water supply or re-use	Low	• Unchanged	Low
		Drainage	• Provides stormwater drainage from residential areas • Transferred to Lake Ranfurly East	High	• Could receive greater volume of urban stormwater, potential to divert stormwater flows that currently enter Murray River	Very high

Receiving Environment	Locations	Value type	Characteristics	Current ranking	Potential uses / values to be enhanced or protected	Potential ranking
Lake Hawthorn	Mildura, Merbein	Environmental	• Extensive habitat • Rare and threatened birds and fish • Possible rare and threatened fauna	Very high	• Protect current environmental values • Survey for rare and threatened flora • Ensure runoff from new residential development does not threaten values	Very high
		Cultural	• As for Lake Ranfurly	Moderate	• Investigate possible cultural sites	High
		Amenity	• Passive recreation values eg bird watching • Secondary contact recreation eg sailing	High	• Potential for high visual amenity from new urban development • Potential for revegetation around shore margins to improve visual amenity and environmental values	Very high
		Economic	• Not currently suitable for water supply or re-use	Low	• Potential for re-use if quality and quantity can be guaranteed	High
		Drainage	• Lake provides dilution of stormwater and drainage pollution • Transfer lake to Wargan Basins	Very high	• Urban development likely to reduce inflows to lake but may require lake to be operated at a lower level to allow for storm runoff capacity	Very high
Wargan Basins		Environmental	• Highly saline • Wetland area of National Importance (particularly Basins 4 & 5) • High diversity and abundance of rare and threatened avifauna • Possible rare and threatened saltbush flora	Very high	• Protect environmental values	Very high
		Cultural	• Potential location for archaeological sites but no systematic surveys conducted	Moderate	• Investigate possible cultural sites	High
		Amenity	• Popular bird watching location	Moderate	• Passive recreational amenity and nature conservation aspects could be improved with revegetation and interpretive signs	Very high
		Economic	• Not suitable for water supply due to high salinity	Low	• Some potential for re-use prior to water entering basins depending on source, salinity etc.	High
		Stormwater	• Terminal evaporation basin for irrigation drainage and stormwater from Lake Hawthorn and Ranfurly • Operated to prevent saline drainage water and groundwater entering Murray River	Very high	• Unchanged	Very high

Appendix C Detailed threats assessment

■ **Table 12.1. Threats to waterways and wetlands in the study area.**

Activity/landuse	Key pollutants	Cause	Location	Rank
Residential runoff	Sediments Nutrients Litter Organic material Oils and grease Pathogens Heavy metals Pesticides Surfactants	• Excess fertiliser and pesticide application • Washing cars • Poor waste management • Lawn clippings and leaves • Sediment buildup • Illegal discharges and accidental spills eg motor oil, paints • Unpaved roads and road shoulders • Unvegetated nature strips and swale drains • Dog faeces • Litter	• Residential areas in Mildura, Irymple, Red Cliffs and Merbein	High
Industrial runoff	Sediments Nutrients Litter Organic material Oils and grease Pathogens Heavy metals Pesticides Surfactants	• Sediment buildup from traffic • Illegal discharges and accidental spills pose a greater risk because they are independent of rainfall • Poor waste management practices • Vehicle washdowns • Unpaved road shoulders • Unvegetated nature strips	• Industrial areas particularly in Mildura eg San Mateo, Etiwanda and Madden Street drainage catchments • Heavy transport vehicle and railway facilities • Food and agricultural processing plants • Abattoirs (self contained) • Fuel depots • Service stations	Very high
Commercial runoff	Sediments Nutrients Litter Organic material Oils and grease Pathogens Heavy metals Pesticides Surfactants	• Sediment buildup • Poor waste management practices eg overfull bins and lack of awareness • Illegal discharges and accidental spills • Unpaved road shoulders • Littering	• All commercial and retail areas in Mildura, Irymple, Red Cliffs and Merbein	Very high
Construction and development sites	Sediment Litter Nutrients	• Poor erosion and sediment control on construction sites • Poor work practices eg brick and tile cutting activities, vehicle washdown • Poor building waste management practices	• Residential development at Mildura and Irymple • Road construction sites • Commercial and industrial development	Very high
Major highways and arterial roads	Sediment Heavy metals Oils and grease	• Sediment buildup from traffic • Accidental spills • Vehicular deposits (rubber, oils, grease brake dust etc)	• Calder Hwy (15th St), Sturt Hwy (Deakin Av.), 7th St • Transport depots, farm sites • Highway construction sites	Very high

Table 4.2 Cont\..

Activity/landuse	Key pollutants	Cause	Location	Rank
Unstable & degraded waterways	Sediment Nutrients Organic material	• Erosion of stream banks • Poorly controlled stock and recreational access • Loss of vegetation • Weed infestation • Changed flow regime	• Bank erosion at stormwater outlfalls to weir pool (eg. San Mateo (I), Pine Av (F) and Magnolia St (H) drains • Erosion along open drainage channels eg Etiwanda (L), Northwest and Northeast drains to Murray River	High
Sullage and septic tank overflows	Nutrients Pathogens	• Poorly maintained septic systems • Combined stormwater and sullage disposal systems • Poor drainage and wastewater infrastructure maintenance • Failure rate of septic tanks not known	• Rural residential areas outside of sewered areas eg Cureton Ave / Cookes Rd alongside Kings Billabong, Lake Hawthorn • House lots on fruit blocks	Moderate - high
Sewer overflows	Nutrients pathogens	• Cross contamination between sewerage and stormwater systems • Emergency relief structure overflows • Poor drainage and wastewater infrastructure maintenance	• Potential in towns with separate stormwater and sewerage systems • Well managed by Lower Murray Water with very rare overflows	Low
Open spaces, parks and recreational areas	Sediment Nutrients Organic material Litter	• Fertiliser applications • Poor waste and litter management • Grass cuttings	• Golf courses • Public parks and reserves eg Deakin Av median strip, Weir pool foreshore • Sporting ovals, eg aerodrome fields • Caravan parks	Very high
Sale yards	Sediment Nutrients Pathogens	• Sediment buildup • Vehicle washdown • Faecal contamination • Poor waste management • Poor drainage and wastewater infrastructure maintenance	• Sale yards located in Mildura and Yelta have contained waste systems	Low
Horticultural and dryland agricultural runoff and subsurface flows	Nutrients Pesticides Organic material Sediment Salt	• Inefficient irrigation practice eg flood irrigation v drip and sprinkler • Excess fertiliser applications • Chemical spray drift • Accidental and illegal discharge of chemicals to waterways and drainage system	• FMIT and SRWA irrigation districts, private diverters eg, discharges to Murray River via Northwest, Northeast, Etiwanda and Basin 12 drains; discharges to floodplain at Merbein and Red Cliffs; discharges to drainage basins around study area	Very high
Upstream inflows	Sediment Nutrients Litter	• Runoff from upstream catchments	• All waterways (99% of nutrients in the Murray River through the Mallee region are generated outside the region and enter via inflows from upstream)	Very high

Appendix D Sensitivity Criteria

The following tables provide details of the process for determining the sensitivity factor for each threat x value combination in the risk assessment process. These notes provide additional information on the specific criteria used.

- Primary and Secondary Contact Recreation are considered beneficial uses of a waterway under EPA State Environmental Protection Policies. These policies are referred to in determining the sensitivity for each waterway. For example, primary contact recreation activities are those where there is likely to be complete emersion eg swimming, water skiing etc. Secondary contact recreation activities are those where there is likely to be some contact with water but not full emersion eg fishing, boating.
- Water supply is a beneficial use of a waterway under EPA State Environmental Protection Policies. Beneficial uses include potable water supply, stock watering and irrigation.
- The impacts of upstream inflows depend upon the particular pollutants present. The sensitivity from upstream inflows is dependent upon the degree or extent that a particular activity in upstream catchments is occurring and the ability of the stream system to transmit these impacts to downstream reaches.
- Where multiple pollutants are present the impacts can be cumulative so the overall sensitivity of a value from a particular threat or activity increases. For example, the sensitivity of a value to industrial runoff is likely to be higher than the sensitivity to residential runoff because there is a greater probability that industrial runoff will contain a broader range of toxicants.
- The more concentrated a pollutant the greater the sensitivity. For example, the volume of sediment in runoff from construction sites is much greater than that from general residential runoff.

Sediment

Value	Sub-value	Impact	Sensitivity
Environmental	Instream	Overall water quality and instream flora and fauna are generally highly sensitive to sedimentation. The severity of the impact depends upon the current conditions experienced by the community. For example, instream communities in a river with naturally high turbidity and sediment load will be less sensitive to sediment inputs compared to a river or creek with naturally clear waters	Mod. to very high depending on current condition of receiving environment and beneficial use.
	Riparian	Riparian vegetation is generally not impacted upon by sediment load in adjacent waterways. The deposition of sediment on the floodplain during a flooding event can smother vegetation if large loads are present, although sediment deposition also contributes to the fertility of the floodplain by depositing nutrients bound the sediment particles	Low
Cultural	Indigenous	Archaeological sites are generally located high on banks rather than in the stream channel, although fish traps can be located in low lying areas and would be prone to burial if excess sediment is being deposited in the stream channel	Low to Mod. depending upon specific type eg sites located on banks v sites located in the channel
	Non-indigenous	Non-indigenous cultural sites are generally buildings that are not impacted upon be excess sediment	Low
Amenity	Primary Contact Recreation	Primary contact recreation can involve complete emersion in the water. Excess sediment and turbidity can reduce the suitability of a waterway for primary recreation contact.	Mod. to very high depending on beneficial use.
	Secondary Contact Recreation	Secondary and passive recreational activities and visual amenity are compromised by high sediment loads and excessive turbidity	High
	Passive recreation / visual amenity		
Economic	Water supply	Excess sediment and turbidity can severely impact upon the value of water for water supply purposes and results in the increases in treatment costs.	Low to very high depending upon beneficial use.
	Tourism	Clean water for swimming etc is highly valued by tourists.	High
	Flood prevention & asset protection	Excess sediment can accumulate in drains and pipes reducing pipe capacity and contributing to flooding	High to very high depending upon the design capacity of the drainage system and the degree of threat

Litter

Value	Sub-value	Description	Sensitivity
Environmental	Instream	Excessive litter can entangle wildlife but does generally not impact upon instream flora and fauna. The severity of the impact depends upon the likely presence of susceptible species eg platypus, fish, birds.	Mod.
	Riparian	Litter per se does generally not impact upon riparian vegetation, although excessive litter build-up on banks can prevent regeneration and damage plants.	Low to Mod.
Cultural	Indigenous	Litter does not directly impact upon Cultural and heritage sites.	Low
	Non-indigenous		
Amenity	Primary Contact Recreation	Highly sensitive	Low to very high depending on beneficial use
	Secondary Contact Recreation	Highly sensitive	High
	Passive recreation / visual amenity	Excess litter has a very high impact upon the visual amenity of an area.	Very high
Economic	Water supply	Excess litter can impact upon the value of water for water supply purposes and results in the increases in treatment costs.	Low to very high depending on beneficial use
	Tourism	Clean water for recreational activities and amenity is highly valued by tourists.	Very high
	Flood prevention & asset protection	Excess litter can accumulate in drains and pipes reducing pipe capacity and contributing to flooding	High to very high depending upon the design capacity of the drainage system and the degree of threat

Nutrients

Value	Sub-value	Description	Sensitivity
Environmental	Instream	Excessive nutrient can contribute to the development of nuisance plant growth and algal blooms. Blue-green algal blooms can produce toxins that impact upon instream fauna and other values.	Very high
	Riparian	Excess nutrients per se do generally not impact upon riparian vegetation, although high nutrient levels can promote weed growth.	Mod.
Cultural	Indigenous	Cultural and heritage sites are not impacted upon directly by excessive nutrients.	Low
	Non-indigenous		
Amenity	Primary Contact Recreation	Excessive nutrients that contribute to nuisance plant growth can impact upon the ability to use a waterbody for primary and secondary recreation. Blue-green algal blooms result in the closure of waterbodies for all recreation activities where there may be the possibility of contact with humans and other animals.	Low to very high depending on beneficial use
	Secondary Contact Recreation		
	Passive recreation / visual amenity	Nuisance plant growth and algal blooms can impact upon the visual amenity of a waterbody and create odours that detract from passive enjoyment	Very high
Economic	Water supply	Excess nutrients can impact upon the value of water for water supply purposes and results in the increases in treatment costs. Toxins due to blue-green algal blooms can prevent water being used for a range of purposes	Low to very high depending on beneficial use
	Tourism	Clean water for recreational activities and amenity is highly valued by tourists.	Very high
	Flood prevention & asset protection	Excessive plant growth as a result of excess nutrients can potentially block pipes and drains and contribute to flooding problems.	High to very high depending upon the design capacity of the drainage system and the degree of threat

Toxicants (heavy metals, surfactants, oil/grease, pesticides)

Value	Sub-value	Description	Sensitivity
Environmental	Instream	Toxicants can have a particularly severe impact upon instream fauna, even in small concentrations.	Very high
	Riparian	Some toxicants may impact upon riparian vegetation if present in large quantities in overland flow.	Mod.
Cultural	Indigenous	Cultural and heritage sites are not impacted upon directly by toxicants.	Low
	Non-indigenous		
Amenity	Primary Contact Recreation	Excessive toxicants can make water unsuitable for primary and secondary contact recreation and in high concentrations, access to waterbodies for recreation may be restricted.	Low to very high depending on beneficial use
	Secondary Contact Recreation		
	Passive recreation / visual amenity	Toxicants can impact upon the visual amenity of a waterbody and create odours that detract from passive enjoyment (eg oil slicks)	Very high
Economic	Water supply	Toxicants can impact upon the value of water for water supply purposes and results in the increases in treatment costs or prevent water from being used for a range of purposes	Low to very high depending on beneficial use
	Tourism	Clean water for recreational activities and amenity is highly valued by tourists.	Very high
	Flood prevention & asset protection	Excessive toxicants are unlikely to impact upon the ability of the stormwater system to convey flood flows, however highly corrosive material could damage pipes and other infrastructure.	Low

Organic material and other oxygen demanding material

Value	Sub-value	Description	Sensitivity
Environmental	Instream	Excessive organic material depletes oxygen and can be detrimental to instream fauna. Severe oxygen depletion can occur following runoff after long periods of dry weather if there has been a build up of organic material in the stormwater drainage system.	Mod.
	Riparian	High organic material is unlikely to impact upon riparian vegetation	Low
Cultural	Indigenous	Cultural and heritage sites are not impacted upon directly by organic material.	Low
	Non-indigenous		
Amenity	Primary Contact Recreation	Excessive organic material can make water unsuitable for primary and secondary contact recreation at times, although this is dependent upon the buildup of material and the frequency of rainfall events.	Low to very high depending on beneficial use
	Secondary Contact Recreation		
	Passive recreation / visual amenity	Excessive organic material can impact upon the visual amenity of a waterbody and create odours that detract from passive enjoyment (eg oil slicks)	High
Economic	Water supply	Organic material can impact upon the value of water for water supply purposes and results in the increases in treatment costs, especially if the organic material is in a particulate form.	Low to very high depending on beneficial use
	Tourism	Clean water for recreational activities and amenity is highly valued by tourists.	High
	Flood prevention & asset protection	Excessive organic material in its particulate form (leaves branches etc) can block pipes and contribute to flooding.	Very high

Microbiological contamination

Value	Sub-value	Description	Sensitivity
Environmental	Instream	Microbiological contamination can have a range of impacts on instream fauna. Waterfowl, fish and other animals may be susceptible to particular bacteria eg Botulism. The degree of impact depends on the particular pathogen, its source and concentration.	Low to high depending on potential for sewer overflows, septic tank effluent or other sources of contamination
	Riparian	Unlikely to have detrimental impact	Low
Cultural	Indigenous	No detrimental impact	Low
	Non-indigenous		
Amenity	Primary Contact Recreation	Microbiological contamination has a significant impact upon recreational activities. Excessive contamination can impact upon human health and lead to the closure of waterways to certain activities.	Mod. to very high depending on beneficial use and mostly related to rainfall events
	Secondary Contact Recreation		
	Passive recreation / visual amenity	Passive recreation and visual amenity are unlikely to be directly impacted upon by microbiological contamination, although aspects of the environment, such as the presence of waterfowl etc, that contribute to amenity will be impacted upon as indicated above. Depending upon the source of contamination odours can be associated with microbiological contamination.	Mod.
Economic	Water supply	Microbiological contamination can impact upon the value of water for water supply purposes and results in the increases in treatment costs, especially if the organic material is in a particulate form.	Low to very high depending on beneficial use
	Tourism	Clean water for recreational activities and amenity is highly valued by tourists.	High
	Flood prevention & asset protection	Microbiological contamination will not impact upon flood prevention.	Low

Flow and erosion

Value	Sub-value	Description	Sensitivity
Environmental	Instream	Increased flow as a result of rapid runoff can cause bank erosion that contributes to sedimentation and turbidity. Erosion around outfalls also contribute to sedimentation. The impacts are similar to that for sediment.	Mod. to very high
	Riparian	Increased flow and erosion of outlets can have a significant impact upon bank stability and riparian vegetation and channels can become wider or more incised.	Very high
Cultural	Indigenous	Bank erosion can threaten cultural and heritage sites depending upon their exact locations.	Low to very high depending upon location
	Non-indigenous		
Amenity	Primary Contact Recreation	Bank erosion can restrict access and create dangerous conditions that threaten safety for both primary and secondary recreational contact activities.	Low to very high depending on beneficial use
	Secondary Contact Recreation		
	Passive recreation / visual amenity	Excessive bank erosion can threaten pathways and flooding can restrict access at times impacting upon passive recreational opportunities and amenity	Mod. to High
Economic	Water supply	Similar impact to sedimentation	Low to very high depending on beneficial use
	Tourism	Excessive erosion and waterway degradation can reduce tourism potential.	High
	Flood prevention & asset protection	Excessive erosion can threaten public and private assets and contribute to increased maintenance costs.	Very high

Appendix E Risk Assessment Matrices

Murray River below Lock 11				STORMWATER THREAT: residential runoff 4	Industrial runoff (Merbein area) 2	Commercial runoff (Merbein area) 2	Construction sites - Lot scale 3	Construction sites - Development 3	Runoff from highways & arterials 3	sullage/septic tank overflows (Threat is high in rural areas) 3	Runoff from Council managed open space, parks and gardens 2	Inflows from upstream reaches 3	Agricultural drainage inflows 4	Waterway and riparian degradation 2	Values most threatened
VALUE	Environmental	Ecological	4	3 / 48	3 / 24	3 / 24	2 / 24	3 / 36	3 / 36	2 / 24	3 / 24	3 / 36	3 / 48	3 / 24	**348**
		Riparian	4	1 / 16	4 / 32	1 / 8	1 / 12	2 / 24	1 / 12	1 / 12	2 / 16	2 / 24	2 / 32	4 / 32	220
	Cultural	Indigenous	4	1 / 16	1 / 8	1 / 8	1 / 12	1 / 12	1 / 12	1 / 12	1 / 8	1 / 12	1 / 16	4 / 32	148
		Non-Indigenous	4	1 / 16	1 / 8	1 / 8	1 / 12	1 / 12	1 / 12	1 / 12	1 / 8	1 / 12	1 / 16	3 / 24	140
	Amenity	Recreational	4	3 / 48	3 / 24	3 / 24	2 / 24	3 / 36	2 / 24	4 / 48	3 / 24	3 / 36	3 / 48	2 / 16	**352**
		Tourism	4	2 / 32	2 / 16	2 / 16	1 / 12	2 / 24	1 / 12	2 / 24	2 / 16	2 / 24	2 / 32	2 / 16	**224**
		Visual / Passive	4	2 / 32	2 / 16	2 / 16	2 / 24	2 / 24	1 / 12	2 / 24	2 / 16	2 / 24	2 / 32	2 / 16	236
	Economic	Water supply	4	3 / 48	3 / 24	3 / 24	2 / 24	3 / 36	2 / 24	3 / 36	2 / 16	3 / 36	3 / 48	2 / 16	**332**
	Drainage	Flood protection	3	1 / 12	1 / 6	1 / 6	1 / 9	1 / 9	1 / 9	1 / 9	1 / 6	1 / 9	1 / 12	1 / 6	93
		Reduced nutrient & salt loads to Murray	1	1 / 4	1 / 2	1 / 2	1 / 3	1 / 3	1 / 3	1 / 3	1 / 2	1 / 3	1 / 4	1 / 2	31
	Greatest threats			**272**	160	136	156	**216**	156	204	136	216	**288**	**184**	

Very high priority | High priority | Moderate priority | Low priority

Murray River above Lock 11				STORMWATER THREAT: Residential runoff 4	Industrial runoff (Mildura area) 4	Commercial runoff (Mildura area) 4	Construction sites - Lot scale 3	Construction sites - Development 3	Runoff from highways & arterials 4	sullage/septic tank overflows (Threat is high in rural areas) 3	Runoff from Council managed open space, parks and gardens 3	Inflows from upstream reaches 3	Agricultural drainage inflows 4	Waterway and riparian degradation 3	Values most threatened
VALUE	Environmental	Ecological	4	3 / 48	4 / 64	3 / 48	2 / 24	3 / 36	4 / 64	2 / 24	3 / 36	3 / 36	4 / 64	3 / 36	480
		Riparian	4	1 / 16	2 / 32	2 / 32	1 / 12	1 / 12	2 / 32	1 / 12	1 / 12	2 / 24	2 / 32	4 / 48	264
	Cultural	Indigenous	4	1 / 16	1 / 16	1 / 16	1 / 12	1 / 12	1 / 16	1 / 12	1 / 12	1 / 12	1 / 16	4 / 48	188
		Non-Indigenous	4	1 / 16	1 / 16	1 / 16	1 / 12	1 / 12	1 / 16	1 / 12	1 / 12	1 / 12	1 / 16	3 / 36	176
	Amenity	Recreational	4	3 / 48	4 / 64	3 / 48	3 / 36	4 / 48	3 / 48	4 / 48	3 / 36	3 / 36	4 / 64	3 / 36	512
		Tourism	4	2 / 32	2 / 32	2 / 32	2 / 24	2 / 24	2 / 32	2 / 24	2 / 24	3 / 36	2 / 32	2 / 24	316
		Visual / Passive	4	3 / 48	3 / 48	3 / 48	3 / 36	3 / 36	3 / 48	2 / 24	2 / 24	1 / 12	2 / 32	3 / 36	392
	Economic	Water supply	4	3 / 48	4 / 64	3 / 48	3 / 36	4 / 48	4 / 64	3 / 36	2 / 24	3 / 36	4 / 64	3 / 36	504
	Drainage	Flood protection	3	1 / 12	1 / 12	1 / 12	1 / 9	1 / 9	1 / 12	1 / 9	1 / 9	1 / 9	1 / 12	1 / 9	114
		Reduced nutrient & salt loads to Murray	1	1 / 4	1 / 4	1 / 4	1 / 3	1 / 3	1 / 4	1 / 3	1 / 3	1 / 3	1 / 4	1 / 3	38
	Greatest threats			288	352	304	204	240	336	204	192	216	336	312	

Very high priority | High priority | Moderate priority | Low priority

Kings Billabong				STORMWATER THREAT											Values most threatened
				rural residential runoff	Industrial runoff (Mildura area)	Commercial runoff (Mildura area)	Construction sites - Lot scale	Construction sites - Development	Runoff from highways & arterials	sullage/septic tank overflows (Threat is high in rural areas)	Runoff from Council managed open space, parks and gardens	Inflows from upstream reaches	Agricultural drainage inflows	Waterway and riparian degradation	
				3	0	0	3	3	2	4	2	3	3	3	
VALUE	Environmental	Ecological	4	3 / 36	0 / 0	0 / 0	3 / 36	3 / 36	1 / 8	4 / 64	2 / 16	3 / 36	3 / 36	3 / 36	**304**
		Riparian	4	1 / 12	0 / 0	0 / 0	2 / 24	2 / 24	1 / 8	2 / 32	1 / 8	2 / 24	2 / 24	2 / 24	180
	Cultural	Indigenous	4	1 / 12	0 / 0	0 / 0	1 / 12	1 / 12	1 / 8	1 / 16	1 / 8	1 / 12	1 / 12	4 / 48	140
		Non-Indigenous	4	1 / 12	0 / 0	0 / 0	1 / 12	1 / 12	1 / 8	1 / 16	1 / 8	1 / 12	1 / 12	3 / 36	128
	Amenity	Recreational	4	3 / 36	0 / 0	0 / 0	2 / 24	3 / 36	2 / 16	4 / 64	2 / 16	3 / 36	3 / 36	2 / 24	**288**
		Tourism	3	2 / 18	0 / 0	0 / 0	1 / 9	2 / 18	1 / 6	3 / 36	1 / 6	2 / 18	2 / 18	2 / 18	**147**
		Visual / Passive	4	3 / 36	0 / 0	0 / 0	3 / 36	3 / 36	2 / 16	2 / 32	2 / 16	2 / 24	2 / 24	2 / 24	**244**
	Economic	Water supply	3	3 / 27	0 / 0	0 / 0	1 / 9	3 / 27	2 / 16	3 / 36	2 / 12	4 / 36	3 / 27	2 / 18	**208**
	Drainage	Flood protection	1	1 / 3	0 / 0	0 / 0	1 / 3	1 / 3	1 / 2	1 / 4	1 / 2	1 / 3	1 / 3	1 / 3	26
		Reduced nutrient & salt loads to Murray	2	1 / 6	0 / 0	0 / 0	1 / 6	1 / 6	1 / 4	1 / 8	1 / 4	1 / 6	1 / 6	1 / 6	52
Greatest threats				**198**	0	0	171	**210**	92	**308**	96	**207**	**198**	**237**	

Very high priority | High priority | Moderate priority | Low priority

Psyche Bend Lagoon				STORMWATER THREAT											Values most threatened
				rural residential runoff	Industrial runoff (Mildura area)	Commercial runoff (Mildura area)	Construction sites - Lot scale	Construction sites - Development	Runoff from highways & arterials	sullage/septic tank overflows (Threat is high in rural areas)	Runoff from Council managed open space, parks and gardens	Inflows from upstream reaches	Agricultural drainage inflows	Waterway and riparian degradation	
				1	0	0	0	0	1	1	1	0	3	3	
VALUE	Environmental	Ecological	1	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1	3 / 3	1 / 1	0 / 0	3 / 9	3 / 9	**24**
		Riparian	1	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1	1 / 1	1 / 1	0 / 0	2 / 6	2 / 6	16
	Cultural	Indigenous	2	1 / 2	0 / 0	0 / 0	0 / 0	0 / 0	1 / 2	1 / 2	1 / 2	0 / 0	1 / 6	2 / 12	**26**
		Non-Indigenous	1	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1	1 / 1	1 / 1	0 / 0	1 / 3	1 / 3	10
	Amenity	Recreational	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1	1 / 1	1 / 1	0 / 0	1 / 3	1 / 3	9
		Tourism	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
		Visual / Passive	1	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1	1 / 1	1 / 1	0 / 0	1 / 3	1 / 3	10
	Economic	Water supply	1	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1	1 / 1	1 / 1	0 / 0	1 / 3	1 / 3	10
	Drainage	Flood protection	2	1 / 2	0 / 0	0 / 0	0 / 0	0 / 0	1 / 2	1 / 2	1 / 2	0 / 0	1 / 6	1 / 6	20
		Reduced nutrient & salt loads to Murray	4	1 / 4	0 / 0	0 / 0	0 / 0	0 / 0	1 / 4	1 / 4	1 / 4	0 / 0	2 / 24	1 / 12	**52**
Greatest threats				13	0	0	0	0	14	16	14	0	**63**	**57**	

Very high priority | High priority | Moderate priority | Low priority

Basin 12

				STORMWATER THREAT											
				residential runoff	Industrial runoff (Red Cliffs area)	Commercial runoff (Red Cliffs area)	Construction sites - Lot scale	Construction sites - Development	Runoff from highways & arterials	sullage/septic tank overflows (Threat is high in rural areas)	Runoff from Council managed open space, parks and gardens	Inflows from upstream reaches	Agricultural drainage inflows	Waterway and riparian degradation	**Values most threatened**
				3	**2**	**2**	**2**	**1**	**3**	**3**	**3**	**0**	**4**	**2**	
VALUE	Environmental	Ecological	**3**	3 / 27	3 / 18	3 / 18	2 / 12	2 / 6	2 / 18	3 / 27	2 / 18	1 / 0	3 / 36	2 / 12	**192**
		Riparian	**3**	2 / 18	2 / 12	1 / 6	1 / 6	1 / 3	2 / 18	2 / 18	1 / 9	1 / 0	2 / 24	2 / 12	**126**
	Cultural	Indigenous	**2**	1 / 6	1 / 4	1 / 4	1 / 4	1 / 2	1 / 6	1 / 6	1 / 6	1 / 0	3 / 24	2 / 8	70
		Non-Indigenous	**1**	1 / 3	1 / 2	1 / 2	1 / 2	1 / 1	1 / 3	1 / 3	1 / 3	1 / 0	1 / 4	1 / 2	25
	Amenity	Recreational	**2**	1 / 6	1 / 4	1 / 4	1 / 4	1 / 2	1 / 6	1 / 6	1 / 6	1 / 0	2 / 16	1 / 4	58
		Tourism	**1**	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
		Visual / Passive	**2**	2 / 12	1 / 4	2 / 8	1 / 4	2 / 4	1 / 6	2 / 12	2 / 12	1 / 0	3 / 24	3 / 12	98
	Economic	Water supply	**1**	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Drainage	Flood protection	**3**	1 / 9	1 / 6	1 / 6	1 / 6	1 / 3	1 / 9	1 / 9	1 / 9	1 / 0	2 / 24	1 / 6	87
		Reduced nutrient & salt loads to Murray	**4**	1 / 12	1 / 8	1 / 8	1 / 8	1 / 4	1 / 12	1 / 12	1 / 12	1 / 0	2 / 32	1 / 8	**116**
	Greatest threats			**93**	58	56	46	25	**78**	**93**	75	0	**184**	64	

Very high priority | High priority | Moderate priority | Low priority

Cardross Lakes

				STORMWATER THREAT											
				residential runoff (includes some rural surface run-off)	Industrial runoff (Red Cliffs area)	Commercial runoff (Red Cliffs area)	Construction sites - Lot scale	Construction sites - Development	Runoff from highways & arterials	sullage/septic tank overflows (Threat is high in rural areas)	Runoff from Council managed open space, parks and gardens	Inflows from upstream reaches	Agricultural drainage inflows	Waterway and riparian degradation	**Values most threatened**
				1	**0**	**0**	**1**	**0**	**1**	**3**	**1**	**0**	**4**	**2**	
VALUE	Environmental	Ecological	**4**	2 / 8	0 / 0	0 / 0	1 / 4	0 / 0	1 / 4	2 / 24	1 / 4	0 / 0	4 / 64	3 / 24	**132**
		Riparian	**4**	2 / 8	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 12	0 / 0	0 / 0	3 / 48	2 / 16	**84**
	Cultural	Indigenous	**1**	1 / 1	0 / 0	0 / 0	1 / 1	0 / 0	1 / 1	1 / 3	1 / 1	0 / 0	3 / 12	2 / 4	23
		Non-Indigenous	**1**	1 / 1	0 / 0	0 / 0	1 / 1	0 / 0	1 / 1	1 / 3	1 / 1	0 / 0	1 / 4	1 / 2	13
	Amenity	Recreational	**1**	1 / 1	0 / 0	0 / 0	1 / 1	0 / 0	1 / 1	3 / 9	1 / 1	0 / 0	3 / 12	3 / 6	**31**
		Tourism	**1**	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 4	0 / 0	4
		Visual / Passive	**1**	2 / 2	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 6	0 / 0	0 / 0	3 / 12	3 / 6	26
	Economic	Water supply	**1**	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Drainage	Flood protection	**2**	1 / 2	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 8	1 / 4	14
		Reduced nutrient & salt loads to Murray	**2**	1 / 2	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	3 / 24	1 / 4	**30**
	Greatest threats			**25**	0	0	7	0	7	**57**	7	0	**188**	**66**	

Very high priority | High priority | Moderate priority | Low priority

Koolong Basins				STORMWATER THREAT												Values most threatened
				residential runoff (includes some rural surface run-off)	Industrial runoff (Red Cliffs area)	Commercial runoff (Red Cliffs area)	Construction sites - Lot scale	Construction sites - Development	Runoff from highways & arterials	sullage/septic tank overflows (Threat is high in rural areas)	Runoff from Council managed open space, parks and gardens	Inflows from upstream reaches	Agricultural drainage inflows	Waterway and riparian degradation	
				1	0	0	0	0	1	3	1	0	4	1	
VALUE	Environmental	Ecological	1	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1	2 / 6	1 / 1	0 / 0	4 / 16	1 / 1	26
		Riparian	2	1 / 2	0 / 0	0 / 0	0 / 0	0 / 0	1 / 2	1 / 6	1 / 2	0 / 0	3 / 24	1 / 2	38
	Cultural	Indigenous	2	1 / 2	0 / 0	0 / 0	0 / 0	0 / 0	1 / 2	1 / 6	1 / 2	0 / 0	1 / 8	3 / 6	26
		Non-Indigenous	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Amenity	Recreational	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	3 / 12	1 / 1	13
		Tourism	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 4	0 / 0	4
		Visual / Passive	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 6	0 / 0	0 / 0	3 / 12	3 / 3	21
	Economic	Water supply	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Drainage	Flood protection	2	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 8	1 / 2	10
		Reduced nutrient & salt loads to Murray	4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	3 / 48	1 / 4	52
Greatest threats				**5**	0	0	0	0	5	**24**	5	0	**132**	**19**	

Very high priority | High priority | Moderate priority | Low priority

Lake Ranfurly East				STORMWATER THREAT											Values most threatened
				residential runoff (includes some rural surface run-off)	Industrial runoff (Mildura/Irymple area)	Commercial runoff (15th street)	Construction sites - Lot scale	Construction sites - Development	Runoff from highways & arterials	sullage/septic tank overflows (Threat is high in rural areas)	Runoff from Council managed open space, parks and gardens	Inflows from upstream reaches	Drainage inflows from groundwater	Waterway and riparian degradation	
				4	3	4	2	3	3	2	3	0	3	3	
VALUE	Environmental	Ecological	4	48	48	48	24	48	48	16	36	0	48	24	388
		Riparian	4	2 / 32	2 / 24	2 / 32	1 / 12	2 / 32	2 / 32	1 / 8	1 / 12	0 / 0	3 / 48	2 / 16	248
	Cultural	Indigenous	3	1 / 12	1 / 9	1 / 12	0 / 0	1 / 12	0 / 0	0 / 0	0 / 0	0 / 0	2 / 24	3 / 18	87
		Non-Indigenous	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Amenity	Recreational	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
		Tourism	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
		Visual / Passive	3	3 / 36	2 / 18	3 / 36	2 / 18	3 / 36	3 / 36	1 / 6	1 / 9	0 / 0	3 / 36	3 / 18	249
	Economic	Water supply	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Drainage	Flood protection	4	1 / 16	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 16	1 / 8	40
		Reduced nutrient & salt loads to Murray	4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	4 / 64	0 / 0	64
Greatest threats				**144**	99	**128**	54	**128**	116	30	57	0	**236**	84	

Very high priority | High priority | Moderate priority | Low priority

Lake Ranfurly West				STORMWATER THREAT									
				Rural residential runoff	Industrial runoff	Commercial runoff	Construction sites - Lot scale	Construction sites - Development	Runoff from highways & arterials	sullage/septic tank overflows (Threat is high in rural areas)	Runoff from Council managed open space, parks and gardens	Inflows from upstream reaches	Drainage inflows from groundwater	Waterway and riparian degradation
				1	0	0	1	1	1	1	1	0	4	2
VALUE	Environmental	Ecological	4	1 / 4	0 / 0	0 / 0	1 / 4	1 / 4	1 / 4	1 / 4	1 / 4	0 / 0	3 / 48	3 / 24
		Riparian	4	1 / 4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	3 / 48	3 / 24
	Cultural	Indigenous	3	1 / 3	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 24	3 / 18
		Non-Indigenous	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Amenity	Recreational	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
		Tourism	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
		Visual / Passive	1	1 / 1	0 / 0	0 / 0	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	0 / 0	3 / 12	2 / 4
	Economic	Water supply	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Drainage	Flood protection	1	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 4	1 / 2
		Reduced nutrient & salt loads to Murray	4	1 / 4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	4 / 64	0 / 0
Greatest threats				17	0	0	5	5	5	5	5	0	**200**	**72**

Very high priority | High priority | Moderate priority | Low priority

Lake Hawthorn				STORMWATER THREAT										
				residential runoff (includes some rural surface run-off)	Industrial runoff	Commercial runoff	Construction sites - Lot scale	Construction sites - Development	Runoff from highways & arterials	sullage/septic tank overflows (Threat is high in rural areas)	Runoff from Council managed open space, parks and gardens	Inflows from upstream reaches	Agricultural drainage & groundwater inflows	Waterway and riparian degradation	**Values most threatened**
				3	1	1	3	4	3	3	3	0	4	2	
VALUE	Environmental	Ecological	4	3 / 36	2 / 8	2 / 8	3 / 36	3 / 48	3 / 36	3 / 36	2 / 24	0 / 0	3 / 48	3 / 24	**304**
		Riparian	4	2 / 24	0 / 0	0 / 0	1 / 12	2 / 32	2 / 24	1 / 12	1 / 12	0 / 0	3 / 48	3 / 24	**188**
	Cultural	Indigenous	2	1 / 6	0 / 0	0 / 0	0 / 0	1 / 8	0 / 0	0 / 0	0 / 0	0 / 0	2 / 16	4 / 16	46
		Non-Indigenous	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Amenity	Recreational	3	2 / 18	2 / 6	2 / 6	1 / 9	2 / 24	2 / 18	4 / 36	2 / 18	0 / 0	3 / 36	2 / 12	**183**
		Tourism	2	1 / 6	0 / 0	0 / 0	0 / 0	0 / 0	1 / 6	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	12
		Visual / Passive	3	2 / 18	1 / 3	1 / 3	1 / 9	3 / 36	2 / 18	2 / 18	1 / 9	0 / 0	3 / 36	3 / 18	**168**
	Economic	Water supply	1	1 / 3	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 0	3 / 12	1 / 2	17
	Drainage	Flood protection	4	2 / 24	1 / 4	1 / 4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 32	1 / 8	72
		Reduced nutrient & salt loads to Murray	4	1 / 12	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	3 / 48	0 / 0	60
Greatest threats				**147**	21	21	66	**148**	**102**	102	63	0	**276**	104	

Very high priority | High priority | Moderate priority | Low priority

Wargan Basins				STORMWATER THREAT											Values most threatened
				residential runoff (includes some rural surface run-off) 0	Industrial runoff 0	Commercial runoff 0	Construction sites - Lot scale 0	Construction sites - Development 0	Runoff from highways & arterials 0	sullage/septic tank overflows (Threat is high in rural areas) 0	Runoff from Council managed open space, parks and gardens 0	upstream inflows (from Lake Ranfurly & Lake Hawthorn) 4	Drainage inflows (local catchment) 2	degraded waterways 3	
VALUE	Environmental	Ecological	4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	3 / 48	3 / 24	3 / 36	**108**
		Riparian	4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	3 / 48	3 / 24	3 / 36	**108**
	Cultural	Indigenous	2	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 8	1 / 4	1 / 6	18
		Non-Indigenous	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Amenity	Recreational	3	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 12	1 / 6	1 / 9	27
		Tourism	2	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
		Visual / Passive	3	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 24	2 / 12	2 / 18	**54**
	Economic	Water supply	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Drainage	Flood protection	4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 32	2 / 16	0 / 0	48
		Reduced nutrient & salt loads to Murray	4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	3 / 48	3 / 24	0 / 0	**72**
Greatest threats				0	0	0	0	0	0	0	0	**220**	**110**	**105**	

Very high priority | High priority | Moderate priority | Low priority

Riffle Butts Swamp				STORMWATER THREAT											Values most threatened
				residential runoff (includes some rural surface run-off) 4	Industrial runoff (land fill) 2	Commercial runoff (Deakin Av, Schools & Hospital) 3	Construction sites - Lot scale 3	Construction sites - Development 4	Runoff from highways & arterials 3	sullage/septic tank overflows (Threat is high in rural areas) 2	Runoff from Council managed open space, parks and gardens 3	Inflows from upstream reaches 0	Agricultural drainage inflows 2	Waterway and riparian degradation 3	
VALUE	Environmental	Ecological	2	4 / 32	3 / 12	3 / 18	3 / 18	4 / 32	3 / 18	2 / 8	2 / 12	0 / 0	3 / 12	3 / 18	**180**
		Riparian	2	2 / 16	2 / 8	1 / 6	1 / 6	2 / 16	1 / 6	1 / 4	1 / 6	0 / 0	2 / 8	3 / 18	**94**
	Cultural	Indigenous	2	1 / 8	1 / 4	1 / 6	1 / 6	1 / 8	1 / 6	1 / 4	1 / 6	0 / 0	1 / 4	3 / 18	70
		Non-Indigenous	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Amenity	Recreational	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
		Tourism	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
		Visual / Passive	3	2 / 24	2 / 12	2 / 18	1 / 9	2 / 24	1 / 9	1 / 6	1 / 9	0 / 0	2 / 12	3 / 27	**150**
	Economic	Water supply	1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Drainage	Flood protection	3	2 / 24	1 / 6	1 / 9	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 6	1 / 9	54
		Reduced nutrient & salt loads to Murray	2	1 / 8	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 4	0 / 0	12
Greatest threats				**112**	42	**57**	39	**80**	39	22	33	0	46	**90**	

Very high priority | High priority | Moderate priority | Low priority

Lamberts Swamp				STORMWATER THREAT												Values most threatened
				residential runoff (includes some rural surface run-off)	Industrial runoff (Red Cliffs area)	Commercial runoff (15th street)	Construction sites - Lot scale	Construction sites - Development	Runoff from highways & arterials	sullage/septic tank overflows (Threat is high in rural areas)	Runoff from Council managed open space, parks and gardens	upstream inflows	Drainage inflows (groundwater)	degraded waterways	
				1	**0**	**0**	**1**	**0**	**1**	**3**	**1**	**0**	**4**	**1**	
VALUE	Environmental	Ecological	**1**	2 / 2	0 / 0	0 / 0	1 / 1	0 / 0	1 / 1	2 / 6	0 / 0	0 / 0	4 / 16	2 / 2	**28**
		Riparian	**1**	1 / 1	0 / 0	0 / 0	1 / 1	0 / 0	1 / 1	1 / 3	0 / 0	0 / 0	3 / 12	2 / 2	**20**
	Cultural	Indigenous	**1**	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 4	1 / 1	6
		Non-Indigenous	**1**	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Amenity	Recreational	**1**	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
		Tourism	**1**	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
		Visual / Passive	**1**	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 3	0 / 0	0 / 0	3 / 12	1 / 1	**17**
	Economic	Water supply	**1**	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0
	Drainage	Flood protection	**1**	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 4	1 / 1	5
		Reduced nutrient & salt loads to Murray	**4**	1 / 4	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	4 / 64	0 / 0	68
	Greatest threats			**9**	0	0	2	0	2	12	0	0	**112**	7	

Very high priority High priority Moderate priority Low priority

Appendix F Reactive Management Actions

Shaded actions are those not recommended for implementation. Where the same action appears more than once, costs have not been shared, however repeat actions are indicated in the final recommended actions for implementation. The information in this table is summarised in Table 8.3.

Risk	Strategy	Action Element	Code	Life time yr	Capital cost $	ongoing cost $/yr	Total cost $	% catchment	Effectiveness	Effective Life cycle yr	Feasibility	Multiple benefit	Score
64	**1**	**Industrial runoff, Murray River above lock 11**											
		Long term consultation in partnership with EPA to target industrial operations	O	10		$2,000	$20,000	100	M	10	VH	H	63
		Workshops for emergency and operations staff	E,O	1	$5,000		$5,000	100	M	3	VH	M	74
		Update emergency response planning	O	10	$20,000	$2,000	$40,000	100	M	10	H	VH	127
		Workshops for Industry representatives	E,O	1	$5,000		$5,000	100	L	2	VH	L	309
		GPT on combined San Mateo / Etiwanda Drain (622 ha)	I	20	$200,000	$5,000	$300,000	96	H	20	VH	H	354
		Combined wetland for San Mateo and Etiwanda Drains as per SKM concept design (622 ha)	I	40	$800,000	$10,000	$1,200,000	96	VH	40	VH	VH	429
		Literature and guidelines for industry groups	E	2	$15,000	$3,000	$21,000	100	L	5	H	L	667
		Site Audits and Inspections	O	5	$5,000	$20,000	$105,000	100	M	5	VH	M	933
		Environmental Management plans for large industries & new development	O	5	$30,000		$30,000	100	L	5	l	m	1333
		Consultation with individual industries	E	5	$20,000	$2,000	$30,000	100	M	5	m	N	4800
		Revision and enforcement of local laws to highlight stormwater management	O	10	$20,000	$50,000	$520,000	100	l	10	l	VH	6420
		Pipeline along foreshore with diversion to wetland	I	40	$750,000	$10,000	$1,150,000	100	H	40	N	VH	9127
		Pipeline along foreshore with diversion inland to Rifle Butts Swamp	I	40	$1,500,000	$10,000	$1,900,000	100	VH	40	N	VH	11728

Risk	Strategy	Action Element	Code	Life time yr	Capital cost $	ongoing cost $/yr	Total cost $	% catchment	Effectiveness	Effective Life cycle yr	Feasibility	Multiple benefit	Score
64	**2**	**Road runoff from Deakin Av, 7th St and Sturt Hwy to Murray River above lock 11**											
		Liaise with Vic Roads & ensure water sensitive road design for new roads & upgrades and guidelines and education purposes	P	5		$1,000	$5,000	100	H	5	VH	H	23
		Workshops for emergency and operations staff	E,O	1	$5,000		$5,000	100	M	3	VH	M	74
		Update emergency response planning	O	10	$20,000	$2,000	$40,000	100	M	10	H	VH	127
		Combined wetland for San Mateo and Etiwanda Drains as per SKM concept design	I	40	$800,000	$10,000	$1,200,000	96	VH	40	H	VH	551
		Investigate options for retro fitting major highways with grass swales and detention structures designed to isolate spills	P	1	$15,000		$15,000	50	H	1	M	H	1224
		Investigate options for reducing the risk to the LMWA water supply intake from an accidental spill on Chaffey Bridge	I	40	$10,000		$10,000	1	H	40	m	m	1429
		Literature and guidelines for transport and freight industry	E	2	$10,000	$2,000	$14,000	100	L	5	n	L	6222
64	**3**	**Sullage and Septic tank overflows from Kings Billabong LDRZ**											
		Ensure future development complies with EPA guidelines for on-site wastewater systems. (EPA Publications 629, 746, 747 & SEPP Waters of Victoria) eg Land Capability Assessments	P	10		$1,000	$10,000	100	M	10	VH	H	32
		Education for residents on septic tank maintenance	E	5	$6,000	$2,000	$16,000	100	L	10	VH	M	119
		Wetland on combined outfall from rural residential area	I	40	$300,000	$10,000	$700,000	100	H	40	L	VH	926
		Combined community waste water treatment plant	I	40	$1,500,000	$20,000	$2,300,000	100	VH	40	I	H	3042

Risk	Strategy	Action Element	Code	Life time yr	Capital cost $	ongoing cost $/yr	Total cost $	% catchment	Effectiveness	Effective Life cycle yr	Feasibility	Multiple benefit	Score
48	**4**	**Degraded waterways (Murray River and Kings Billabong)**											
		Liase with NRE, CMA and Parks Victoria to improve floodplain management and implement recommendations from other strategic plans	E	5		$5,000	$25,000	100	M	5	VH	H	159
		Establish riparian vegetation protection via revision of MSS & planning scheme overlays	P	1	$5,000		$5,000	100	M	1	VH	H	159
		Inspect all drain outflows along weir pool foreshore and assess for erosion and damaged infrastructure - prepare works plan	O	1	$5,000		$5,000	100	M	1	VH	H	159
		Conduct works program for rectifying eroding banks (indicative cost)	O,I	5	$50,000	$10,000	$100,000	100	H	5	H	H	583
		Signage to raise community awareness of damage that can be done to waterways and vegetation through uncontrolled access, illegal dumping, grazing etc. Link with other CMA and NRE strategies	E	5	$50,000	$2,000	$60,000	60	L	10	H	M	952
48	**5**	**Commercial / institutional runoff from Pine Av Drain (Catchment F) to Murray River above Lock 11**											
		Workshops for waste management and street cleaning personnel, parks, gardens and maintenance staff	E,O	1	$10,000		$10,000	100	H	3	VH	M	106
		GPT unit on drain outfall (73 ha)	I	20	$100,000	$7,500	$250,000	100	VH	20	VH	H	220
		Educational material and signage for bins and side entry pit lids to highlight link between what is dropped in the street and river	E	2	$25,000	$5,000	$35,000	100	I	5	VH	H	370
		Workshops for business owners		1	$5,000		$5,000	100	n	2	m	L	3333
		Brochures for commercial shop owners to highlight better waste management	E	2	$20,000	$2,000	$24,000	100	N	5	VH	L	3556
		Litter baskets in side entry pits around CBD	I,O	5	$20,000	$10,000	$70,000	50	L	5	N	M	###
48	**6**	**Residential runoff above Lock 11**											
		Promote use of rainwater tanks for gardens and investigate feasibility for using grey water for toilet flushing, including an investigation of options for reducing cost to residents.	P,E	10	$10,000	$1,000	$20,000	100	L	20	VH	M	74
		Workshops for waste management and street cleaning personnel, parks, gardens and maintenance staff	E,O	1	$10,000		$10,000	100	H	3	VH	M	106
		Media releases to highlight stormwater management issues to the general community	E	1	$2,500		$2,500	100	I	1	VH	M	185
		Promote Waterwatch and Ecorecycle programs through local schools	E	5	$5,000	$5,000	$30,000	100	M	5	VH	M	267

Risk	Strategy	Action Element	Code	Life time yr	Capital cost $	ongoing cost $/yr	Total cost $	% catchment	Effectiveness	Effective Life cycle yr	Feasibility	Multiple benefit	Score
		GPT on San Mateo / Etiwanda Drain as per SKM Etiwanda Wetland Concept design (622 ha)	I	20	$200,000	$7,500	$350,000	96	VH	20	VH	H	322
		Review & assess the types of recycling bins used and potential for litter escape	O,P	1	$5,000		$5,000	100	L	1	VH	M	370
		Combined wetland for San Mateo and Etiwanda Drains as per SKM concept design (622 ha)	I	40	$800,000	$10,000	$1,200,000	96	VH	40	VH	VH	429
		Educational material for residents wrt car washing, garden practices, encourage waste reduction	E	5	$20,000	$5,000	$45,000	100	L	5	VH	M	667
		Revision and enforcement of local laws to highlight stormwater management	O	10	$20,000	$50,000	$520,000	100	M	10	H	VH	1651
48	**7**	**Residential Runoff below lock 11**											
		Promote use of rainwater tanks for gardens and investigate feasibility for using grey water for toilet flushing, including an investigation of options for reducing cost to residents.	P,E	10	$10,000	$1,000	$20,000	100	L	20	VH	M	74
		Workshops for waste management and street cleaning personnel, parks, gardens and maintenance staff	E,O	1	$10,000		$10,000	100	H	3	VH	M	106
		Investigate re-routing of outflow from Merbein to LMWA treatment ponds	I	1	$10,000		$10,000	100	VH	1	VH	VH	137
		GPT / CDS unit on outflow from Merbein township to floodplain (77ha)	I	20	$60,000	$5,000	$160,000	100	VH	20	H	VH	141
		GPT / CDS unit on outflow from catchment A (64 ha)	I	20	$60,000	$5,000	$160,000	100	VH	20	H	H	181
		GPT / CDS unit on combined outflow from catchments B & D (79 ha)	I	20	$60,000	$5,000	$160,000	100	VH	20	H	H	181
		Media releases to highlight stormwater management issues to the general community	E	1	$2,500		$2,500	100	L	1	VH	M	185
		Promote Waterwatch and Ecorecycle programs through local schools	E	5	$5,000	$5,000	$30,000	100	M	5	VH	M	267
		Review & assess the types of recycling bins used and potential for litter escape	O,P	1	$5,000		$5,000	100	L	1	VH	M	370
		Educational material for residents wrt car washing, garden practices, encourage waste reduction	E	5	$15,000	$5,000	$40,000	100	L	5	VH	M	593
		Revision and enforcement of local laws to highlight stormwater management	O	10	$20,000	$50,000	$520,000	100	M	10	H	VH	1651
		Construct wetland on outflow to floodplain from Merbein township	I	40	$150,000	$10,000	$550,000	100	I	40	I	m	3056

Risk	Strategy	Action Element	Code	Life time yr	Capital cost $	ongoing cost $/yr	Total cost $	% catchment	Effectiveness	Effective Life cycle yr	Feasibility	Multiple benefit	Score
48	**8**	**Construction site runoff - Development (all catchments)**											
		Training for council & referral authority staff highlighting requirements of the Planning & Environment Act 1987		**1**	$5,000		$5,000	100	H	2	VH	M	79
		Workshops for council planning and engineering staff involved in internal referrals to ensure best practice management options are considered in planning applications & conditions	P,O	1	$5,000		$5,000	100	H	2	VH	M	79
		Determine applicability of different WSUD principles given unique characteristics in Mildura for all new developments (eg detention systems, re-use for watering, swales etc by the development and distribution of guidelines etc)	P	1	$20,000		$20,000	100	m	5	h	m	229
		Information workshops for developers, builders, contractors and consultants	P,O	1	$10,000		$10,000	100	H	1	VH	M	317
		Develop guidelines for and require sediment and erosion control plans for all new developments	P,O	10	$20,000	$3,000	$50,000	100	L	10	H	H	340
		Increased frequency of audits and inspections of development sites and ensure appropriate infringement notification and enforcement of planning permit conditions		10		$30,000	$300,000	100	VH	10	H	H	680
		Employ dedicated officer for dealing with stormwater/environmental and planning issues	P	10	$20,000	$75,000	$770,000	100	VH	10	VH	VH	1056
		Require developers to clean drainage system & not connect to system until land is stabilised (cost is borne as part of improved audit and inspections process)	P	10		$20,000	$200,000	100	I	10	M	H	1905
48	**9**	**Inflows to Wargan Basins from Lakes Hawthorn and Ranfurly**											
		Addressed in part by managing urban inflows to Lakes Hawthorn and Ranfurly											
48	**10**	**Sullage and septic tank overflows (all catchments & see above)**											
		Ensure future development complies with EPA guidelines for on-site wastewater systems. (EPA Publications 629, 746, 747 & SEPP Waters of Victoria)	P	10	$5,000	$1,000	$15,000	100	M	10	VH	H	48
		Document unsewered areas and report on potential for environmental problems as per EPA publication 629 which requires annual reporting	O	10	$10,000	$500	$15,000	100	M	10	M	M	120
		Education for residents on septic tank maintenance	E	5	$15,000	$2,000	$25,000	100	M	5	VH	VH	123
		Investigate potential for sewering of or local treatment for problem areas	P,O	3	$15,000	$2,000	$21,000	100	M	3	VH	VH	173

Risk	Strategy	Action Element	Code	Life time yr	Capital cost $	ongoing cost $/yr	Total cost $	% catchment	Effectiveness	Effective Life cycle yr	Feasibility	Multiple benefit	Score
48	**11**	**Residential runoff to Lake Ranfurly East**											
		Promote use of rainwater tanks for gardens and investigate feasibility for using grey water for toilet flushing, including an investigation of options for reducing cost to residents.	P,E	10	$10,000	$1,000	$20,000	100	L	20	VH	M	74
		Workshops for waste management and street cleaning personnel, parks, gardens and maintenance staff	E,O	1	$10,000		$10,000	100	H	3	VH	M	106
		Retrofit lagoon on outflow to Lake Ranfurly from 15th St drain to provide wetland treatment (investigate potential for including outflow from catchment Y)		40	$60,000	$5,000	$260,000	85	H	40	H	VH	173
		Media releases to highlight stormwater management issues to the general community	E	1	$2,500		$2,500	100	I	1	VH	M	185
		GPT unit on 15th street drain	I	30	$150,000	$7,500	$375,000	100	VH	30	H	VH	220
		Promote Waterwatch and Ecorecycle programs through local schools	E	5	$5,000	$5,000	$30,000	100	M	5	VH	M	267
		Review & assess the types of recycling bins used and potential for litter escape	O,P	1	$5,000		$5,000	100	L	1	VH	M	370
		Educational material for residents wrt car washing, garden practices, encourage waste reduction	E	5	$15,000	$5,000	$40,000	100	L	5	VH	M	593
		Revision and enforcement of local laws to highlight stormwater management	O	10	$20,000	$50,000	$520,000	100	M	10	H	VH	1651
48	**12**	**Commercial Runoff from 15th street precinct to Lake Ranfurly East**											
		Retrofit lagoon on outflow to Lake Ranfurly from 15th St drain to provide wetland treatment (investigate potential for including outflow from catchment Y)		40	$50,000	$5,000	$250,000	85	VH	40	VH	VH	101
		Workshops for waste management and street cleaning personnel, parks, gardens and maintenance staff	E,O	1	$10,000		$10,000	100	H	3	VH	M	106
		GPT unit on 15th Street drain	I	30	$60,000	$7,500	$285,000	100	VH	30	H	VH	168
		Signage for bins and side entry pit lids to highlight link between what is dropped in the street and river	E	2	$5,000	$5,000	$15,000	100	N	5	VH	H	952
		Workshops for business owners		1	$5,000		$5,000	100	N	2	M	L	3333
		Brochures for commercial shop owners to highlight better waste management	E	2	$20,000	$2,000	$24,000	100	N	5	VH	L	3556

Risk	Strategy	Action Element	Code	Life time yr	Capital cost $	ongoing cost $/yr	Total cost $	% catchment	Effectiveness	Effective Life cycle yr	Feasibility	Multiple benefit	Score
48	**13**	**Road runoff from Deakin Av & 15th St to Lake Ranfurly East**											
		Liaise with Vic Roads & ensure water sensitive road design for new roads & upgrades	P	5		$1,000	$5,000	100	H	5	VH	H	23
		Workshops for emergency and operations staff	E,O	1	$5,000		$5,000	100	M	3	VH	M	74
		Update emergency response planning	O	10	$20,000	$2,000	$40,000	100	M	10	H	VH	127
		Retrofit lagoon on outflow to Lake Ranfurly from 15th St drain to provide wetland treatment (investigate potential for including outflow from catchment Y)		40	$60,000	$5,000	$260,000	85	H	40	H	VH	173
		Investigate options for retro fitting major highways with grass swales and detention structures designed to isolate spills	P	1	$15,000		$15,000	50	H	1	M	H	1224
		Literature and guidelines for transport and freight industry	E	2	$10,000	$2,000	$14,000	100	L	5	N	L	6222
48	**14**	**Industrial runoff from Irymple to Lake Ranfurly East**											
		Long term consultation in partnership with EPA to target industrial operations	O	10		$2,000	$20,000	100	M	10	VH	H	63
		Workshops for emergency and operations staff	E,O	1	$5,000		$5,000	100	M	3	VH	M	74
		Update emergency response planning	O	10	$20,000	$2,000	$40,000	100	M	10	H	VH	127
		Retrofit lagoon on outflow to Lake Ranfurly from 15th St drain to provide wetland treatment		40	$60,000	$5,000	$260,000	100	H	40	H	VH	147
		Workshops for Industry representatives	E,O	1	$5,000		$5,000	100	L	2	VH	L	309
		Maintain trash racks at Irymple retarding basin	I	5		$5,000	$25,000	100	I	5	H	M	476
		Literature and guidelines for industry groups	E	2	$15,000	$3,000	$21,000	100	L	5	H	L	667
		Site Audits and Inspections	O	5	$5,000	$20,000	$105,000	100	M	5	VH	M	933
		Environmental Management plans for large industries & new development	O	5	$30,000		$30,000	100	L	5	L	M	1333
		Consultation with individual industries	E	5	$20,000	$2,000	$30,000	100	M	5	M	N	4800
		Revision and enforcement of local laws to highlight stormwater management	O	10	$20,000	$50,000	$520,000	100	L	10	L	VH	6420

Risk	Strategy	Action Element	Code	Life time yr	Capital cost $	ongoing cost $/yr	Total cost $	% catchment	Effectiveness	Effective Life cycle yr	Feasibility	Multiple benefit	Score
		Pipeline along foreshore with diversion to wetland	I	40	$750,000	$10,000	$1,150,000	100	H	40	N	VH	9127
		Pipeline along foreshore with diversion inland to Rifle Butts Swamp	I	40	$1,500,000	$10,000	$1,900,000	100	VH	40	N	VH	11728
36	**15**	**Upstream inflows to weir pool**											
		Continue liaison & negotiation with MDBC and GMW to investigate options for pulsing flows through Euston Weir pool to reduce the potential for algal blooms as per Mallee WQ strategy & MDBC flows projects	P,O	5		$2,500	$12,500	100	M	5	VH	VH	62
		Establish long term consultation with regional authorities to highlight the impacts that upstream activities have on water quality in Mildura as recommended in Mallee WQ Strategy	P,O	5		$5,000	$25,000	100	H	5	VH	VH	88
36	**16**	**Construction site runoff - lot scale (all catchments)**											
		Promote use of Literature and guidelines to encourage improved stormwater management via better waste management at the lot scale	E	5		$3,000	$15,000	100	M	5	VH	M	133
		Workshops for developers, builders, contractors and consultants	P,O	1	$10,000		$10,000	100	M	1	VH	M	444
		Revision and enforcement of local laws to highlight stormwater management	O	10	$20,000	$50,000	$520,000	100	M	10	H	VH	1651
36	**17**	**Rural residential runoff from Kings Billabong LDRZ**											
		Promote use of rainwater tanks for gardens and investigate feasibility for using grey water for toilet flushing, including an investigation of options for reducing cost to residents.	P,E	10	$10,000	$1,000	$20,000	100	L	20	VH	M	74
		Media releases to highlight stormwater management issues to the general community	E	1	$2,500		$2,500	100	L	1	VH	M	185
		Promote Waterwatch and Ecorecycle programs through local schools	E	5	$5,000	$5,000	$30,000	100	M	5	VH	M	267
		Workshops for waste management and street cleaning personnel, parks, gardens and maintenance staff	E,O	1	$10,000		$10,000	100	H	1	VH	M	317
		Review & assess the types of recycling bins used and potential for litter escape	O,P	1	$5,000		$5,000	100	L	1	VH	M	370
		Educational material for residents wrt car washing, garden practices, encourage waste reduction	E	5	$15,000	$5,000	$40,000	100	L	5	VH	M	593
		Wetland on combined outfall from rural residential area	I	40	$300,000	$10,000	$700,000	100	H	40	L	VH	926
		Revision and enforcement of local laws to highlight stormwater management	O	10	$20,000	$50,000	$520,000	100	M	10	H	VH	1651

Risk	Strategy	Action Element	Code	Life time yr	Capital cost $	ongoing cost $/yr	Total cost $	% catchment	Effectiveness	Effective Life cycle yr	Feasibility	Multiple benefit	Score
36	**18**	**Runoff from open spaces, parks and gardens (all catchments)**											
		Revise operational and maintenance procedures eg, fertiliser application rates, irrigation etc	O	5	$10,000	$5,000	$35,000	100	VH	5	VH	M	173
		Workshops for waste management and street cleaning personnel, parks, gardens and maintenance staff	E,O		$10,000		$10,000	100	H	1	VH	M	317
		Investigate options for re-use of stormwater for irrigating parks and gardens, particularly as part of detention systems in new development	P,O		$20,000		$20,000	100	M	1	H	H	816
36	**19**	**Residential runoff to Lake Hawthorn**											
		Promote use of rainwater tanks for gardens and investigate feasibility for using grey water for toilet flushing, including an investigation of options for reducing cost to residents.	P,E	10	$10,000	$1,000	$20,000	100	L	20	VH	M	74
		Workshops for waste management and street cleaning personnel, parks, gardens and maintenance staff	E,O	1	$10,000		$10,000	100	H	3	VH	M	106
		Media releases to highlight stormwater management issues to the general community	E	1	$2,500		$2,500	100	L	1	VH	M	185
		treatment wetland and WSUD on proposed 16th street drain		40	$350,000	$10,000	$750,000	100	VH	40	VH	VH	257
		Review & assess the types of recycling bins used and potential for litter escape	O,P	1	$5,000		$5,000	100	L	1	VH	M	370
		Educational material for residents wrt car washing, garden practices, encourage waste reduction	E	5	$15,000	$5,000	$40,000	100	L	5	VH	M	593
		Retrofit Centenary park retarding basin to provide low flow wetland treatment		40	$50,000	$10,000	$450,000	100	H	40	L	H	765
		Revision and enforcement of local laws to highlight stormwater management	O	10	$20,000	$50,000	$520,000	100	M	10	H	VH	1651
36	**20**	**Road runoff from Calder Hwy to Lake Hawthorn**											
		Liaise with Vic Roads & ensure water sensitive road design for new roads & upgrades	P	5		$1,000	$5,000	100	H	5	VH	H	23
		Workshops for emergency and operations staff	E,O	1	$5,000		$5,000	100	M	3	VH	M	74
		Update emergency response planning	O	10	$20,000	$2,000	$40,000	100	M	10	H	VH	127
		Monitoring to determine effectiveness of all stormwater initiatives	O,E	5	$10,000	$10,000	$60,000	100	H	5	VH	VH	212
		Investigate options for retro fitting major highways with grass swales and detention structures designed to isolate spills	P	1	$15,000		$15,000	50	H	1	M	H	1224
		Literature and guidelines for transport and freight industry	E	2	$10,000	$2,000	$14,000	100	L	5	N	L	6222

Risk	Strategy	Action Element	Code	Life time yr	Capital cost $	ongoing cost $/yr	Total cost $	% catchment	Effectiveness	Effective Life cycle yr	Feasibility	Multiple benefit	Score
32	**21**	**Industrial runoff from Merbein to Murray River**											
		Long term consultation in partnership with EPA to target industrial operations	O	5		$2,000	$10,000	100	M	5	H	H	82
		Workshops for emergency and operations staff	E,O	1	$5,000		$5,000	100	M	2	VH	M	111
		Update emergency response planning	O	5	$20,000		$20,000	100	M	5	H	VH	127
		Investigate re-routing of outflow from Merbein to LMWA treatment ponds	I	1	$10,000		$10,000	100	VH	1	VH	VH	137
		GPT / CDS unit on outflow to floodplain	I	20	$60,000	$5,000	$160,000	100	VH	20	H	VH	141
		Workshops for Industry representatives	E,O	1	$5,000		$5,000	100	L	2	VH	L	309
		Literature and guidelines	E	2	$15,000	$3,000	$21,000	100	L	5	H	L	667
		Site Audits and Inspections	O	5	$5,000	$20,000	$105,000	100	M	5	VH	M	933
		Environmental Management plans for large industries & new development	O	5	$30,000		$30,000	100	L	5	L	M	1333
		Revision and enforcement of local laws to highlight stormwater management	O	10	$20,000	$50,000	$520,000	100	M	10	H	VH	1651
		Construct wetland on outflow to floodplain from Merbein township	I	40	$150,000	$10,000	$550,000	100	M	40	L	M	1833
		Consultation with individual industries	E	5	$20,000	$2,000	$30,000	100	M	5	M	N	4800
32	**22**	**Residential runoff to Rifle Butts Swamp**											
		Promote use of rainwater tanks for gardens and investigate feasibility for using grey water for toilet flushing, including an investigation of options for reducing cost to residents.	P,E	10	$10,000	$1,000	$20,000	100	L	20	VH	M	74
		Workshops for waste management and street cleaning personnel, parks, gardens and maintenance staff	E,O	1	$10,000		$10,000	100	H	3	VH	M	106
		Media releases to highlight stormwater management issues to the general community	E	1	$2,500		$2,500	100	L	1	VH	M	185
		Review & assess the types of recycling bins used and potential for litter escape	O,P	1	$5,000		$5,000	100	L	1	VH	M	370
		Educational material for residents wrt car washing, garden practices, encourage waste reduction	E	5	$15,000	$5,000	$40,000	100	L	5	VH	M	593
		Sediment and GP traps on major drain outfalls		40	$250,000	$15,000	$850,000	75	H	40	M	H	1156
		Revision and enforcement of local laws to highlight stormwater management	O	10	$20,000	$50,000	$520,000	100	M	10	H	VH	1651
		investigate feasibility of reuse on golf course		1	$10,000		$10,000	25	H	1	L	M	3810