LODDON RIVER
ENVIRONMENTAL WATERING PLAN

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

ASSESSMENT AREA: LODDON RIVER, LODDON WEIR TO MURRAY RIVER, INCLUDING TWELVE MILE CREEK

PREPARED FOR THE
NORTHERN VICTORIA IRRIGATION RENEWAL PROJECT

Northern Victoria Irrigation Renewal Project
NVIRP

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Front cover photo: Loddon River Reach 5, 5th November 2009, North Central CMA

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EXECUTIVE SUMMARY

The Loddon River Environmental Watering Plan (EWP) documents the approach to mitigating the potential impacts of the Northern Victoria Irrigation Renewal Project (NVIRP) due to significant reductions in channel outfalls to the waterway.

This EWP refers to the Loddon River from Loddon Weir to confluence with the Murray River, or reaches 4 and 5 of the environmental flow recommendations. It also includes the Twelve Mile Creek (anabranch of the Loddon River Reach 4).

The following components are the primary means by which the commitment of no net environmental loss for the Loddon River will be achieved for the NVIRP project. The main conclusions are summarised below.

Defining the environmental values of Loddon River
The Loddon River supports a range of environmental values and are described specifically for the lower Loddon River (e.g. Murray Cod). In describing the waterway values, an emphasis has been placed on current condition, identifying listed flora and fauna species, and vegetation communities followed by the environmental flow recommendation that support and sustain the river (e.g. spring freshes to cue native fish movement).

Lower Loddon River environmental flow recommendations
The environmental flow recommendations for the lower Loddon River were reviewed and updated in 2010 to take into consideration knowledge advances and climatic conditions which have impacted on the water availability to the Loddon system. This review provided the environmental context that the mitigation water assessment was based on.

Hydrology assessment)
The assessment of the impact of NVIRP (outfall reductions) on streamflow was undertaken for the long-term, recent (post 2000) and 2004/05 baseline year conditions. The post NVIRP hydrology assessment has largely focused on the impact during the irrigation season (August to April), due to the influence of reduced outfalls over this time period.

Assessment of mitigation water requirement
Mitigation water is defined as the volume of water required to ensure no net impacts on high environmental values resulting from NVIRP. The outcomes from this assessment are summarised below:

- *Loddon River Reach 4:* the assessment demonstrated that the **outfall water provides benefit** to Loddon River Reach 4 and that the provision of mitigation water is warranted if it is managed for environmental purposes. Loddon River Reach 4 has multiple incidental water sources, some of which incur losses between the irrigation system and the waterway. These losses can be avoided via delivery of mitigation water from Loddon Weir, therefore the NET annualised BMW has been calculated

  The incidental water at origin was 752 ML in the baseline year and the NET annual baseline mitigation water volume was calculated as 624 ML. The overall Mitigation Water Commitment (MWC) for Loddon River Reach 4 is 83%, although the MWC for each outfall will apply in the annual calculation of mitigation water. This will be used to calculate the interim mitigation water share of any annually calculated water savings.

- *Twelve Mile Creek:* the assessment demonstrated that the **outfall water <u>does not</u> provide benefit** to Twelve Mile Creek. Therefore mitigation water is not required to maintain the environmental values of the waterway.

- *Loddon River Reach 5:* the assessment demonstrated that the **outfall water provides** benefit to Loddon River Reach 5 and that the provision of mitigation water is warranted if it is managed for environmental purposes. Loddon River Reach 5 has multiple incidental water sources, some of which incur losses between the irrigation system and the waterway. These losses can be avoided via delivery of mitigation water from Kerang Weir, therefore the NET annualised BMW has been calculated.

The incidental water at origin was 1861 ML in the baseline year and the NET annual baseline mitigation water volume was calculated as 1814 ML. The overall Mitigation Water Commitment (MWC) for Loddon River Reach 5 is 97.5%, although the MWC for each outfall will apply in the annual calculation of mitigation water.

The source of mitigation water will be provided by the 'Kerang Fishway and operation of the lower Loddon River Memorandum of Understanding' (Kerang Fishway MoU) - the application of the operational rules outlined in this MoU will meet all summer base-flow and summer fresh environmental flow recommendations and will mitigate the impacts of reduced channel outfall through implementation of NVIRP works. If this mitigation water source (Kerang Fishway MoU) cannot be supplied, the mitigation water commitment will be required from other sources.

Potential risks, limiting factors and adverse impacts associated with the recommended water regime

A number of potential risks, limiting factors and adverse impacts have been identified that may result from the provision of mitigation water as a portion of the recommended water regime. For example, if the Loddon River Reach 5 source of mitigation water (Kerang Fishway MoU) cannot be supplied, the mitigation water commitment will be required from other sources (e.g. NVIRP Gross water savings).

Adaptive management framework

An adaptive management approach (assess, design, implement, monitor, review and adjust) is incorporated into the EWP to ensure that it is responsive to changing conditions.

The Loddon River EWP has been developed using the best available information. However, a number of information and knowledge gaps are identified in the document which may impact recommendations and/or information presented. These knowledge gaps will be addressed as part of the adaptive management approach outlined within the EWP as additional information becomes available.

Governance arrangements

A summary of the roles and responsibilities (e.g. land manager, environmental water manager, and system operator) relating to the development and implementation of EWPs are defined.

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ACKNOWLEDGEMENTS

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- North Central CMA working group (listed in Appendix A, Table A2)
- Lyndall Rowley, Emer Campbell, Rebecca Horsburgh, Rebecca Lillie and Bridie Velik-Lord (North Central CMA).

ABBREVIATIONS

ANCA	Australian Nature Conservation Agency
ASS	Acid Sulphate Soils
AUSRIVAS	Australian River Assessment System
BE	Bulk Entitlement
BMW	Baseline Mitigation Water
BONN	Convention on the Conservation of Migratory Species
CAMBA	China–Australia Migratory Bird Agreement
DCFL	Department of Conservation Forests and Lands
DEWHA	Department of Environment, Water, Heritage and the Arts
DIWA	Directory of Important Wetlands
DPI	Department of Primary Industries
DPCD	Department of Planning and Community Development
DSE	Department of Sustainability and Environment
EES	Environmental Effects Statement
EPBC	*Environmental Protection and Biodiversity Conservation Act 1999*
ERP	Expert Review Panel
EVC	Ecological Vegetation Class
EWH	Environmental Water Holder
EWP	Environmental Watering Plan
EWR	Environmental Water Reserve
FFG	*Flora and Fauna Guarantee Act 1988*
GIS	Geographic Information Systems
GL	Gigalitre (one billion litres)
GMID	Goulburn Murray Irrigation District
G-MW	Goulburn–Murray Water
JAMBA	Japan–Australia Migratory Bird Agreement
LEWAG	Loddon Environmental Water Advisory Group
Lower Loddon River	Loddon River (Loddon Weir to Murray River)
LTCE	Long-term Cap Equivalent
MWC	Mitigation Water Commitment
North Central CMA	North Central Catchment Management Authority
NVIRP	Northern Victoria Irrigation Renewal Project
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SEMP	Site Environmental Management Plan
TAC	Technical Advisory Committee
TRG	Technical Reference Group
VEAC	Victorian Environmental Assessment Council
WCMF	Water Change Management Framework
WWC	Waranga Western Channel

1. Northern Victoria Irrigation Renewal Project

The Northern Victoria Irrigation Renewal Project (NVIRP) is a $2 billion works program to upgrade ageing irrigation infrastructure across the Goulburn Murray Irrigation District (GMID) and to save water lost through leakage, evaporation and system inefficiencies. Works will include lining and automating channels, building pipelines and installing new, modern metering technology. These combined works will improve the irrigation system's delivery efficiency and recover a long term average (LTCE) of 425 GL of water per year.

The GMID uses a number of natural carriers, rivers, lakes and wetlands for both storage and conveyance of water. While the water savings generated from the NVIRP are considered a 'loss' to the irrigation system, in some cases this operating regime provides incidental benefits to environmental assets (SKM 2008).

1.1. Decision under the Environmental Effects Act 1978

On the 14 April 2009, the Victorian Minister for Planning made a decision that an Environment Effects Statement (EES) was not required for the NVIRP project under the Victorian EES Act 1978, although this decision was subject to several conditions (DPCD 2009). The conditions that apply to the protection of wetlands and waterways include:

Condition 3: *development of a framework for protection of aquatic and riparian ecological values through management of water allocations and flows within the modified GMID system to the satisfaction of the Minister of Water*

NVIRP has developed a Water Change Management Framework (July 2009[1]) in response to this condition. The framework outlines the processes and methodologies for preparing Environmental Watering Plans to mitigate potential impacts on wetlands and waterways at risk from the implementation of the NVIRP through adaptive water management (NVIRP 2010).

Condition 5: *Environmental Watering Plans (EWPs) are required for 'at risk' waterways and wetlands before operation of the relevant NVIRP work commences*

The other relevant environmental legislation that the NVIRP need to be in compliance with is outlined in Appendix B.

1.2. Water Savings Protocol

The "Technical Manual for the quantification of Water Savings" provides guidelines for the calculation of water savings from irrigation modernisation projects (DSE 2009).

1.2.1. Baseline year

To calculate water savings the Technical Manual has adopted a "baseline year" to establish the average asset condition and operation condition of the system prior to modernisation. The baseline year is representative of long term average system conditions (DSE 2009). The selected baseline year for both the Pyramid Boort and Torrumbarry Irrigation Areas is 2004-05[2] (NVIRP 2010).

1.2.2. Long Term Cap Equivalent Conversion Factor

The Long Term Cap Equivalent (LTCE) Conversion Factor converts the savings within any year to be equivalent to the expected long term average under the hydrological and operating conditions for the system (DSE 2009). Refer to Step 6 of Section 8 for how this applies to calculating mitigation water for waterways.

[1] Date to be finalised during final review process for the EWPs

[2] The baseline year is selected for its representativeness (e.g. last 100% allocation year) and focuses the mitigation water assessment on NVIRP activities and excludes those system activities that happened before NVIRP (NVIRP 2010).

1.3. Water Change Management Framework

The Water Change Management Framework (WCMF) (NVIRP 2010) sets out the overarching principles with respect to environmental management for the operation of the modified GMID. These principles include:

- NVIRP will strive for efficiency in both water supply and farm watering systems.
- NVIRP will design and construct the modernised GMID system to comply with environmental requirements as specified in the no-EES conditions.
- NVIRP will develop management and mitigation measures consistent with established environmental policies and programs in place in the GMID.
- Renewal or refurbishment of water infrastructure will be undertaken to the current best environmental practice, including any requirements to better provide environmental water. Best environmental practice will require irrigation infrastructure required to deliver environmental water to be retained (no rationalisation at these sites) or upgraded to allow for future use.
- Management and mitigation measures will be maintained into the future through establishment of, or modification to, operating protocols and operational arrangements.

While NVIRP has been established to implement the modernised works, it will have no ongoing role in the operation of the modified GMID or environmental management in the region. Therefore NVIRP will need to establish effective management arrangements to ensure that any management or mitigation measures are implemented on an ongoing basis, particularly in the EWPs (NVIRP 2010).

1.4. Environmental Referral Report

An Environmental Referrals process assessed Stage 1 (upgrade of the backbone and connections) of the NVIRP in relation to potential impacts on waterways, wetlands and regional groundwater from increased system efficiencies such as changes in channel outfalls, delivery patterns and reductions in leakage and seepage (SKM 2008).

As part of this an assessment of the changes to river flow regimes for the Loddon, Campaspe, Goulburn and Broken rivers was undertaken. The results indicated that overall, the changes in river flow regimes due to NVIRP are small, especially when examined in terms of the annual flow volume. For the Loddon River the impact highlighted was a small decrease in summer flows and small increase in winter flows across all ranges. It was suggested that this change is consistent with environmental flow recommendations.

The preliminary impact assessment of reduced channel outfalls on waterways was found to be variable, depending on the timing and volume of channel outfalls and environmental values in the waterway. Further assessment was recommended for the Loddon River with the following findings:

- Pyramid Boort Irrigation Area[3] (Loddon River Reach 4) – cumulative impact of reduction in channel outfall indicated a detectable change in flows.
- Pyramid Boort Irrigation Area (Twelve Mile Creek) – little information on flow regime is available to assess the impacts of outfall on flow.
- Torrumbarry Irrigation Area[4] (Loddon River Reach 5) – while the assessment found little change as a result of a reduction in channel outfalls, the considerable complexity in this area warranted further investigation.

[3] The section between Loddon Weir and the Macorna Channel is part of the Pyramid-Boort Irrigation Area (supplied from the Goulburn System via Waranga Western Channel).

[4] The section downstream of the Macorna Channel is part of the Torrumbarry Irrigation Area (supplied from the Murray System via National Channel).

1.5. Shortlisting of Environmental Watering Plans

Following the preliminary list of waterways requiring further investigation (SKM 2008), Feehan Consulting (2009) undertook a validation process (confirmation of environmental values and water supply to the site) to short-list the waterways requiring EWPs. The following four waterways with significant environmental values were identified as potentially impacted by an 85% reduction in channel outfalls across the GMID:

1. Campaspe River (downstream of Campaspe Weir to Murray River)
2. Loddon River (downstream of Loddon Weir to Murray River)
3. Twelve Mile Creek (anabranch of the Loddon River)
4. Broken Creek (NVIRP 2010).

1.6. Purpose and scope of Environmental Watering Plans

Where a site with high environmental values could be adversely affected due to the changed irrigation contribution from the implementation of NVIRP or if uncertainty exists as to the materiality of impacts, an EWP is prepared (NVIRP 2010, p66). The purpose of EWPs is to assess the environmental values that may be impacted by an 85% reduction in channel outfall[5].

The EWPs recommend the required mitigation for any of the potential adverse impacts to the waterway due to the implementation of NVIRP and include:

- scoping and collation of background information
- defining the environmental values, ecological objectives and associated water requirements
- assessment of hydrology (natural and current)
- NVIRP impact assessment
- quantification of the required mitigation water
- identification of risks associated with NVIRP
- governance and adaptive management recommendations
- consultation and engagement with stakeholders and adjacent landholders.

This Waterway EWP is not a river restoration plan, therefore it is not intended to provide management guidance; rather it is aimed at providing a water supply protocol that can be agreed upon by the land, water and catchment managers.

Please note: This EWP is assessing the potential impact from NVIRP in relation to outfall water contribution

Please note: leakage and seepage from NVIRP works is difficult to quantify until works have been implemented. The EWP has assumed that NVIRP works contributing to reduced leakage and seepage is minor and has not been further assessed as part of this EWP.

NVIRP is responsible for managing and mitigating the significant environmental effects of its own activities. It is not responsible for managing and mitigating the effects of other activities or circumstances. NVIRP is not responsible for managing and mitigating the environmental effects of activities and circumstances beyond its control such as:

- reduced outfalls due to Government policy initiatives
- water trade
- drought and climate change
- management and modernisation programs carried out by others (NVIRP 2010).

[5] Channel outfalls are unscheduled flows that leave the irrigation system, they are variable being influenced by rainfall, water deliveries, system operations, irrigation demand, crops being irrigated and the length of the irrigation season (DSE, 2009).

NVIRP EWPs will be implemented in the context of:

- an overarching wetland or waterway management plan (that considers integrated land, water and biodiversity management of the waterway), where available.
- Agency roles and responsibilities documented in the WCMF and the Northern Region Sustainable Water Strategy (DSE 2009a):
- Victorian and regional strategies for healthy rivers, estuaries and waterways (still in development).

1.7. EWP Development process

The Loddon River EWP (downstream of Loddon Weir to Murray River) was developed in collaboration with key stakeholders (members of the NVIRP Technical Advisory Committee (TAC), Appendix A) including Goulburn-Murray Water (G-MW), NVIRP, the Department of Sustainability and Environment (DSE), Parks Victoria and the Department of Primary Industries (DPI) according to the process outlined in Figure 1.

This EWP recommends the management and mitigation measures appropriate for long-term implementation. It also includes the processes for monitoring, review and adaptive management (refer to Figure 1).

Following development, EWPs are reviewed by the Technical Reference Group (Section 1.7.3), NVIRP TAC, DSE Approvals Working Group (membership comprised of departmental representatives) and the Expert Review Panel prior to consideration by the Minister for Water.

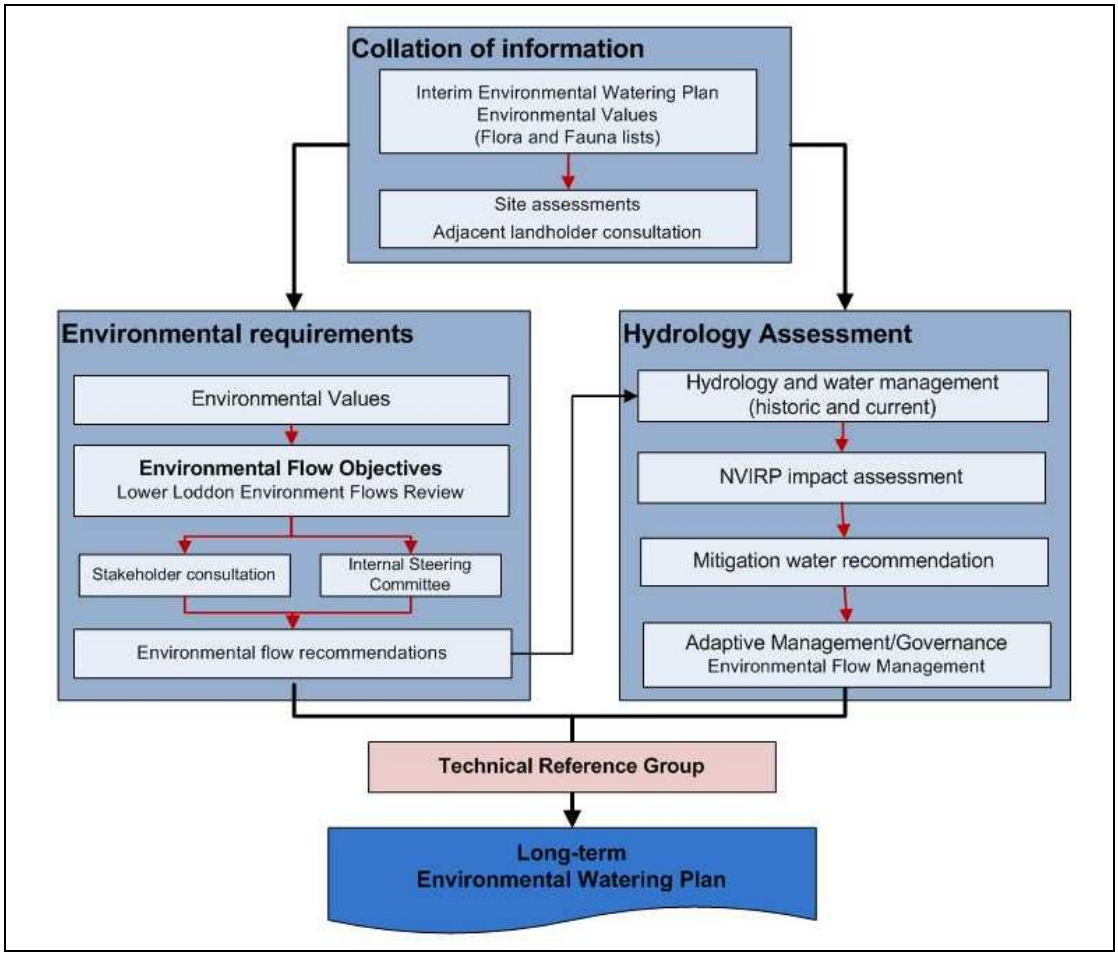

Figure 1: EWP development process

1.7.1. Interim Loddon River EWP

An Interim Environmental Watering Plan for the Loddon River (August 2009) considered the risk to the Loddon River from the NVIRP 2009 winter works program. Conclusions from the Interim EWP for the Loddon River are summarised below:

- The short-term risk assessment from the reduction in the No. 1 channel outfall to the Loddon River was considered to be **low** for both significant species and drought refuge.
- It was recommended that a monitoring program be implemented during the 2009/10 irrigation season to monitor any changes in risk during this period.
- No mitigation actions were required for the 2009-10 irrigation season.

This Loddon River EWP is required to assess the impacts of NVIRP modernisation measures, including reduced outfalls, beyond this timeframe. Subsequent field visits over the 2009-10 season indicated that the short-term risk remained low (site did not dry out over this period) (NCCMA 2009a).

1.7.2. Consultation and engagement

To assist in collating information for the Loddon River EWP, a targeted community and agency engagement process was undertaken. Key groups consulted were the NVIRP Technical Advisory Committee (TAC), agency stakeholders, interest groups and adjoining landholders. An outline of the various groups' involvement is provided below.

The TAC was convened by the NVIRP to oversee the development of the EWPs to ensure quality, completeness and practicality. The committee included representation from CMAs, G-MW, DPI, NVIRP and DSE (Appendix A). A content template for the EWPs was developed and approved by the TAC in February 2010, refer to Attachment E of the Water Change Management Framework (NVIRP 2010).

Consultation was also undertaken with adjoining landholders who have had a long association with the waterway and proven interest in maintaining its environmental value. A summary of the information sourced from this process is provided in Appendix C.

1.7.3. Technical Reference Group

In addition, key components (environmental values, hydrology and mitigation water assessments) of the EWP were presented and reviewed by an independent Technical Reference Group (TRG) comprising of Dr Andrew Sharpe, Kate Austin (SKM), Prof Paul Boon (Dodo Environmental) and John McGuckin (Streamline Research Pty Ltd) on 15 March 2010. This group have had practical and or consulting experience in the Loddon River system (e.g. Environmental Flow Studies) and have provided technical expertise and scientific rigour for this EWP. Refer to Appendix G for paper outlining the recommendations made by the TRG.

2. Loddon River

2.1. Catchment setting

The Loddon River rises on the northern slopes of the Great Dividing Range near Daylesford, and flows north for approximately 430 km to join the Murray River (Figure 2). Cairn Curran and Tullaroop Reservoirs are the main storages that collect water from the upper parts of the catchment. Laanecoorie Reservoir is used as a re-regulating storage for releases from Cairn Curran and Tullaroop Reservoirs (NCCMA 2006). This infrastructure is used to control Loddon River flows for irrigation and domestic water supply; however this has had a major influence on the river's natural flow regime (DSE 2005).

The Loddon River channel decreases in size significantly in the lower/northern reaches. The flat fertile Loddon floodplain receives flood flows as water spills out into a series of break-away creeks. Large volumes of water are absorbed on the Loddon floodplain and the associated interconnecting wetlands.

Loddon River Reach 4 falls entirely within the Victorian Riverina Bioregion and flows for approximately 65 km from Loddon Weir to Kerang Weir. It is characterised by channels and anabranches which distribute water from the river out onto the floodplain. The main land uses in this reach are open grazing and cropping farmland. Twelve Mile Creek is an anabranch which leaves the Loddon River north of Yando and rejoins the Loddon River south of Appin South.

Reach 5 of the Loddon River follows a highly sinuous path for 58 km from Kerang to the Little Murray River at Benjaroop and receives major tributary inputs from Barr Creek (Figure 2). The Loddon River directly influences the health of the Murray River including salinity, flows, and the exchange of aquatic species.

The lower Loddon River forms part of the Loddon River Plains. These plains are enclosed to the east and south by the Central and Eastern Highlands, the low granitic hills of the Terrick Terrick Range in the east and Gredgwin Range and Lunette Ridge in the west. Over Quaternary timescales, sediments have been deposited on the plains by a system of inland flowing streams, many of which died out on the plains. The Loddon River is restricted to a single meandering course through the Central Highlands, confined to the west by Palaeozoic sediments and to the east by Tertiary basalts (Macumber 1969 cited in SKM 2010b).

The Loddon River from Kerang occupies the larger ancestral course of the Goulburn River (active around 10,000-30,000 years BP), which previously entered the ancestral Murray near the current Murrumbidgee confluence (Currey and Dole 1978 cited in SKM 2010b). Channel capacity increases downstream of Kerang due to inflows from Pyramid Creek and the channel capacity increases further downstream of the confluence with Barr Creek.

A system of artificial levees also exists in the lower Loddon River, which isolate areas of floodplain from inundation during overbank flow events and alter flood flow paths (Rob O'Brien, *pers comm.,* 2010).

2.2. Loddon River EWP

This EWP refers to the Loddon River from Loddon Weir to confluence with the Murray River, or reaches 4 and 5 in the environmental flow recommendations. It also includes the Twelve Mile Creek (anabranch of the Loddon River Reach 4), refer to Figure 2.

An important characteristic of the lower Loddon River (since the early 1920s) is that it is influenced by the Irrigation Supply Systems (Pyramid-Boort[6] and Torrumbarry[7] Irrigation Areas). Irrigation water from the Goulburn system enters the Loddon from the Waranga Western Channel (WWC) to supply and/or transfer water (DSE 2005). The irrigation season is from mid-August to mid-May (approximately 270 days) which is when outfalls into the Loddon River occur.

[6] The section between Loddon Weir and the Macorna Channel is part of the Pyramid-Boort Irrigation Area (supplied from the Goulburn System via Waranga Western Channel).

[7] The section downstream of the Macorna Channel is part of the Torrumbarry Irrigation Area (supplied from the Murray System via National Channel).

Irrigation outfalls currently contribute to flow in the lower Loddon River. These outfalls provide an artificial flow regime which may have some environmental benefit in the Loddon River. The NVIRP is expected to significantly reduce losses from the Pyramid-Boort and Torrumbarry Irrigation Areas (85% target), which may in turn lead to a number of hydrological changes in the Loddon River (NVIRP 2010).

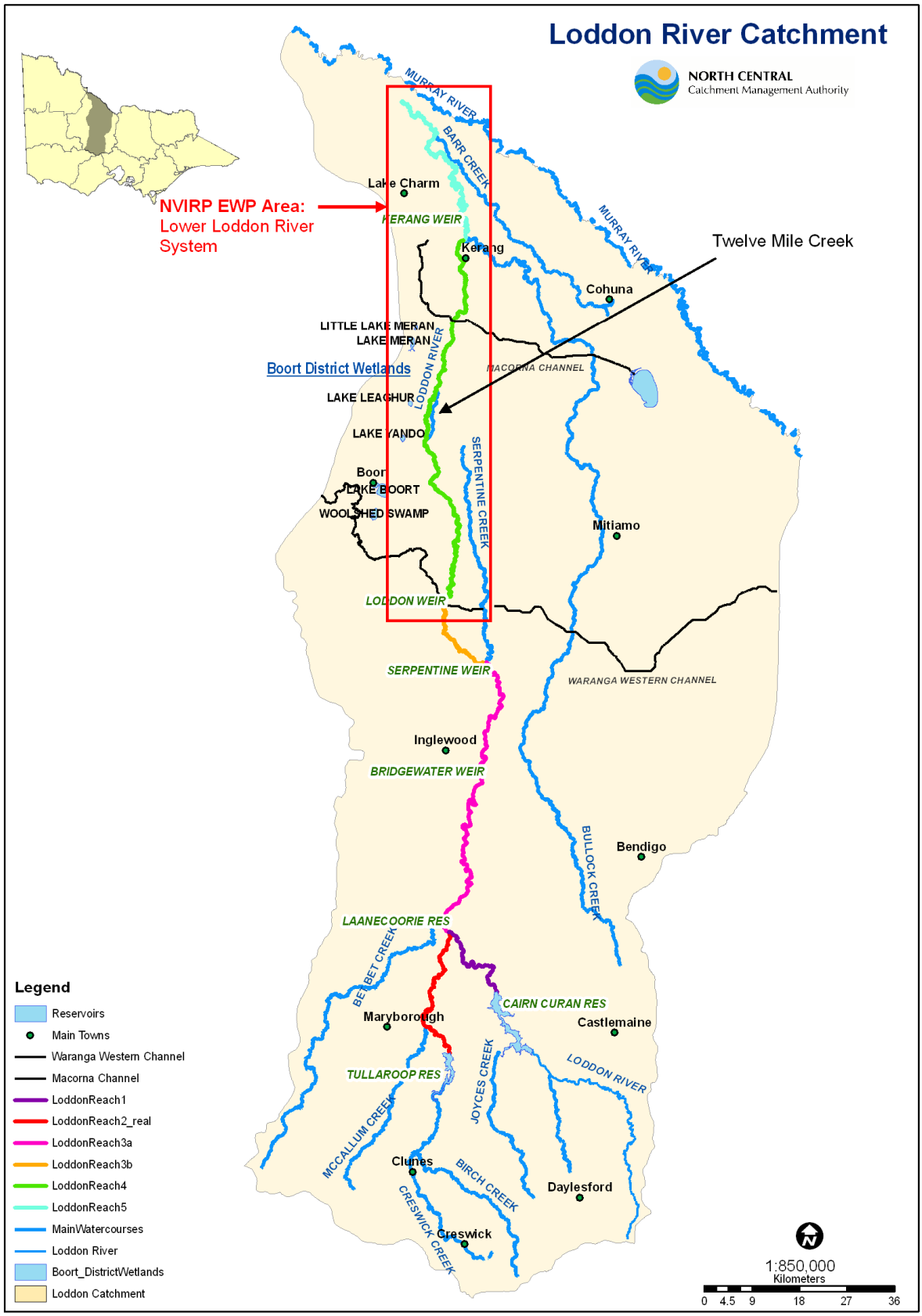

Figure 2: Loddon River Catchment

2.3. Cultural heritage

The lower Loddon catchment is recognised as an important cultural heritage and archaeological region in Victoria. The Loddon River downstream of Kerang is mapped as an area of cultural heritage sensitivity. Traditional owners are the Baraparapa people (Kerang to the Murray River) and Wamba Wamba (junction of the Loddon River and Little Murray River) (DPCD 2008).

A number of registered Aboriginal sites have been located at the junction of Barr Creek and the Loddon River and near the Little Murray River. Several sites (over 200) such as mounds or ovens, graves, scarred trees and surface scatters containing freshwater shells, stone artefacts and burnt clay are recorded (NCCMA 2006).

2.4. Recreation

The lower Loddon River provides opportunities for fishing, camping and swimming. Occasional boating activities have also been recorded in the lower Loddon River (NCCMA 2003). It has a high scenic value river landscape (LCC 1989) and is used informally by tourists.

3. Management objectives

In 2002, the Loddon River Environmental Flows Scientific Panel determined environmental flow requirements for four reaches of the Loddon River between Cairn Curran Reservoir and the Murray River, and for one reach in Tullaroop Creek (LREFSP 2002a). The five environmental flow reaches are described in Table 1 and shown in Figure 2. The flow recommendations for Reaches 1 to 4 were used to develop the Loddon River (Environmental Reserve) Bulk Entitlement (BE) Order 2005 (Victorian Government 2005). The Loddon River downstream of Kerang is managed as part of the Torrumbarry Irrigation System and forms part of the Victorian Murray BE.

Table 1: Loddon River Environmental flow reaches (LREFSP 2002a)

Reach number	Description
Reach 1	Loddon River – Cairn Curran Reservoir to Laanecoorie Reservoir
Reach 2	Tullaroop Creek – Tullaroop Reservoir to Laanecoorie Reservoir
Reach 3a	Loddon River – Laanecoorie Reservoir to Serpentine Weir
Reach 3b	Loddon River – Serpentine Weir to Loddon Weir
Reach 4	Loddon River – Loddon Weir to Kerang Weir
Reach 5	Loddon River – Kerang Weir to Murray River

3.1. Lower Loddon environmental flow reaches

Uncertainty over some of the hydrologic assessments used in the previous environmental flow study (LREFSP 2002) and the rapid change in the condition of the lower Loddon River made it necessary to review the environmental flow requirements for the Loddon River system downstream of Loddon Weir.

The environmental flow recommendations have been reviewed and updated by SKM (2010a, 2010b and 2010c) for the lower Loddon River (refer to Sections 5.1.3, 5.2.3 and 5.3.3). SKM (2010c) has subdivided the two reaches as follows, taking into account the operations, and their hydrological and geomorphological characteristics (illustrated in Figure 3).

Reach 4a: Loddon River between Loddon Weir and the Twelve Mile Creek regulator

Reach 4b: Twelve Mile Creek

Reach 4c: Loddon River from the Twelve Mile Creek regulator to Macorna Channel

Reach 4d: Loddon River from Macorna Channel to Kerang Weir

Reach 5a: Loddon River from Kerang Weir to Barr Creek

Reach 5b: Loddon River from Barr Creek to the Murray River.

Two management aims were established in 2008 (specific to the current dry conditions and Qualification of Rights) in developing the Loddon River Annual Watering Plan:

1. *Ensure as much of the river environmental assets survive during dry sequences.*
2. *Provide assistance to recover environmental health when returning to normal years.*

Estimates of future climate change conditions indicate that the Loddon River catchment will be one of the catchments most severely affected by climate change. Reductions in inflows of 34% under medium climate change conditions and 74% under a continuation of recent dry years by 2055 have been modelled (DSE 2008). If such conditions eventuate, the current cease-to-flow conditions and channel drying may become more prevalent (Section 4.1). This would represent a considerable change to the hydrology of the lower Loddon River (SKM 2010b).

The environmental flow recommendations (SKM 2010c) are presented in Section 5. These recommendations outline the desired watering regime for the Loddon River and are used as part of the calculations for mitigation water (Section 8). Appendix D provides a summary of the method used to determine the environmental flow recommendations and how they relate to particular species and environmental values.

Figure 3: New reach boundaries for the lower Loddon River (SKM 2010b)

3.2. Previous relevant studies, projects and groups

There are a number of river health related projects and programs being implemented along the Loddon River by government agencies, not-for-profit environmental organisations and Landcare groups. Various government agencies co-ordinate a number of projects and programs that feed into the management of water resources in the Loddon River, these include:

- **Environmental Flow Management –** an Environmental Water Reserve (EWR) was established in order to manage environmental water in the Loddon River and Boort District Wetlands via the Bulk Entitlement (Loddon River - Environmental Reserve) Order 2005. The environmental entitlements for the lower Loddon River are summarised in Table 2 below (Victorian Government 2005).

Table 2: Reach 4 Environmental Entitlement

BE Conversion Order	Location	Entitlement
Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005	Loddon River between Loddon Weir and Kerang Weir	Minimum Flows (November to April) plus losses ■ Vary flows over a two week cyclical period, rising from 7 to 12 ML/day in the first week and falling from 12 to 7 ML/day in the next week Minimum Flows (May to October) If combined storage in Cairn Curran and Tullaroop Reservoirs is >60,000 ML: ■ 61 ML/day (plus losses) If combined storage in Cairn Curran and Tullaroop Reservoirs is <60,000 ML: ■ 10 ML/day (plus losses)
		River freshening flow ■ 50 ML/day (plus loses) for 14 days during January or February.
		Rules are also specified for maximum rates of rise and fall, when and how river freshening flows are supplied and how losses are calculated.

Please note: The Loddon River EWR BE is currently under a Temporary Qualifications of Rights and above entitlements are currently not being met.

- **Loddon Environmental Water Advisory Group (LEWAG)** – the LEWAG consists of key stakeholders and community representatives who provide advice on the best use of environmental water for the Loddon River to the North Central CMA (NCCMA 2009b).
- **Loddon Campaspe Drought Response Group (2006 onwards) –** G-MW, North Central CMA, DSE and DPI Fisheries jointly undertake water resource planning for the Loddon and Campaspe rivers. This is undertaken as part of the coordinated drought response management which was developed in order to identify and manage ecological risks and maintain domestic and stock supply during the current drought.
- **G-MW Management –** Bulk Entitlement (Loddon System – Goulburn-Murray Water) Conversion Order 2005. Bulk entitlements define the amount, and the procedure by which, an authority is entitled to take and use water from a waterway. Three bulk entitlement conversion orders allow Goulburn-Murray Water, Coliban Water and Central Highlands Water to divert water from the Loddon River catchment for irrigation and urban supplies.
- **Kerang Weir Fishway –** in 2008, a vertical-slot fishway was constructed on the Loddon River at Kerang Weir and improved fish passage provisions were made at the bridge directly upstream to enable fish movement upstream and into Pyramid Creek. The fishway and associated bridge works connect a 100 km reach of the lower Loddon River to its confluence with the Murray River and is an important link between fish habitats (Stuart, Ryan and McGuckin, 2009).

- **Loddon Stressed Rivers Restoration Project –** since 2003, the North Central CMA has invested State government funds into river health protection and enhancement activities along the regulated reaches of the Loddon River. This large-scale project has aimed to complement the potential river health improvements to be gained through the delivery of environmental flows by implementing a range of integrated activities, including on-ground works in the riparian zone, investigations, capital works and community engagement (NCCMA 2003).
- **Loddon River Water Quality Management:** The lower Loddon River is naturally high in salinity, and stock access and agricultural runoff can increase turbidity and nutrient levels. The lower Loddon River is among the most turbid streams in Victoria (LREFSP, 2002a). Increases in total phosphorus and suspended sediment loads are strongly linked to degradation of water quality. The Loddon Nutrient Action Plan sets out nutrient management actions which are important management units outlined in the North Central River Health Strategy.
- **Loddon River Environmental Flow Studies:** The two environmental flow studies have been completed for the Loddon River are:
    - Loddon River Environmental Flows Scientific Panel (2002b). This was the initial environmental flow study used to develop the Loddon Bulk Entitlement.
    - Review of Environmental Flow Requirements of the Lower Loddon River (Draft) (SKM 2010c). This project has reviewed and updated environmental flow recommendations for the Lower Loddon River (Reach 4 and 5) The Loddon EWP has used the updated draft environmental flow recommendations.

4. Loddon River current condition

The drought has severely impacted on the storage levels in Cairn Curran and Tullaroop reservoirs. The only flows released since early 2007 (Temporary Qualification of Rights introduced to current) have been to supply essential stock and domestic requirements and minimal environmental flows (for example, pulsed environmental flows in Tullaroop Creek). There have been no flows downstream of the Loddon Weir since June 2007 (NCCMA 2008). The Bulk Entitlement for the Loddon River Environmental Water Reserve is currently under a Temporary Qualifications of Rights due to the extreme dry conditions.

4.1. Reach 4 (including Twelve Mile Creek)

The current condition of the Loddon River downstream of Loddon Weir is very poor (SKM 2010b). The dry conditions, combined with the impact of river regulation for irrigation, and adaptive EWR management, mean that parts of the lower Loddon River between Loddon Weir and Kerang have completely dried. Such an event has not occurred previously in the available historical record, however such events most likely occurred prior to regulation.

In response to the river channel drying, River Red Gums have germinated in the bed of the Loddon River (approximately 30 km of the reach). Prior to the cease to flow commencing in 2007 the summer low flow regime coupled with the high sedimentation of the river bed also resulted in the proliferation of Cumbungi and Phragmites at various sites along the reach. The dry river bed has also exposed cracks up to two metres deep. Anecdotal evidence suggests that sites in the lower Loddon River used to have deeper pools. However, silting has occurred in more recent decades and the dry bed has exposed a uniform channel bed. This reach is currently dry and does not have adequate refuges to support any fish.

Sites downstream of Loddon Weir were identified as having acidic sediment and water in 2008. An assessment of acid sulphate soils (ASS) was conducted by Thomas *et al.* (2009) on the lower Loddon River. Soil profiles were taken to test sediments from 27 sites along a 12 km section downstream of Loddon Weir to determine the presence of, and potential for, ASS (Thomas *et al.* 2009). Bright reddish-orange iron oxide, with field pH measures ranging from pH 3 to 4, was commonly observed as coatings or staining on logs and clay soils in the Loddon River bed (Thomas *et al.* 2009).

The results of the sediment testing showed that up to 90% of the lower Loddon River samples had either existing acidity or the potential to produce acid as they oxidise (Thomas *et al.* 2009). Acidity was highest in the streambed and mid stream bars where the ASS material has been exposed to air and where the soil texture is sandy. No ASS materials were observed on elevated banks and terraces (Thomas *et al.* 2009).

During very low flows, there is a greater likelihood that the sediments at the bottom of the river would be anoxic. ASS are likely to pose the greatest threat to the health of the Loddon River at very low flows, without any higher flushes (SKM 2010b).

The channel of Twelve Mile Creek is currently dry and, like Reach 4, is colonised by riparian plants. There are abundant juvenile River Red Gum in the channel and little evidence of recruitment on the banks. There is little evidence of a native shrub layer and the ground layer is mostly grasses. Exotic (pasture) taxa have established within the native swards (SKM 2010b).

4.2. Reach 5

The current condition of the Loddon River downstream of Kerang is poor (SKM 2010b). This is due to several factors including the recent reduction in river flows, over grazing, salinisation and river regulation.

Reach 5 sits lower in the floodplain (not perched) and receives water from the Loddon River, Pyramid Creek and Barr Creek, and interacts with Sheepwash Creek. Its capacity increases further downstream and flows into the Little Murray and Murray rivers. There is significant interaction between Reach 5 and the Murray River (native fish passage). The regulation of the Little Murray River has resulted in significant siltation from the maintained constant water level (O'Brien 2009).

The channel is heavily vegetated with a suite of emergent macrophytes including *Juncus spp* and *Cyperus exaltatus*. The banks are vegetated with dense patches of Tangled Lignum (*Muehlenbeckia florulenta)* and widely spaced River Red Gum. Scattered Black Box occur further back from the channel, sometimes mixed with River Red Gum (SKM 2010b).

Low flows and the lack of good pool habitats has adversely affected fish populations in Reach 5 in recent years. A few deeper pools (>50 cm) remain in this reach, however water quality is very turbid and of poor quality. Most of the deeper holes along the entire lower Loddon are full of silt and no longer act as good fish refuges in times of low flows. However, the lower Loddon does provide refuge for water dependant vegetation and for local birds and other fauna. Low flows have also enabled Cumbungi (*Typha* sp.) to establish in the lower sections of this reach (SKM 2010b).

5. Loddon River environmental values

The Loddon River supports a range of environmental values. These are described specifically for the lower Loddon River (Reach 4, Twelve Mile Creek and Reach 5) (Figure 3) in the following sections.

The primary purpose of this EWP is to assess and advise on mitigating against the potential impacts of NVIRP on the Loddon River's high environmental values. While it is recognised that this waterway provides a number of broader ecological and landscape values (i.e. floodplain processes), high environmental values have previously been defined by the conservation significance of the waterway or species at an international, national or state level (SKM 2008; NVIRP 2010) (refer to Appendix B).

As such, in describing the waterway values in the sections below, an emphasis has been placed on identifying listed flora and fauna species, and vegetation communities followed by the environmental flow recommendation that support and sustain the river. All listed values have been presented in this section with full species lists provided in Appendix E.

5.1. Reach 4

5.1.1. Fauna

Eight native fish species have been recorded in this section of the Loddon River (Appendix E), including three significant species (Table 3). Of the native fish species, one (Murray Cod (*Maccullochella peelii peelii)* is listed under the federal *Environment Protection and Biodiversity Conservation (EPBC) Act 1999,* three are considered migratory, two are listed for protection under the Victorian *Flora and Fauna Guarantee Act (FFG) 1988, and* three are threatened in Victoria. Golden Perch (*Macquaria ambigua*) are stocked at Loddon Weir (DPI 2009). Macroinvertebrate fauna are typical of lowland rivers in composition, but characterised by a low diversity (LREFSP 2002a).

Table 3: Significant fish species recorded in Reach 4 of the Loddon River

Common Name	Scientific Name	EPBC	FFG	VROTS
Golden Perch*	*Macquaria ambigua*			VU
Murray Cod*	*Maccullochella peelii peelii*	VU	L	EN
Silver Perch*	*Bidyanus bidyanus*		L	CR

Conservation Status:

- *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999* Listed: VU – Vulnerable
- FFG listing: L – listed as threatened
- Victorian Rare or threatened Species (VROTS): EN – Endangered, CR – Critical, VU – Vulnerable, DD – Data Deficient (DSE 2007)
- * Migratory

Source: (DSE 2009b)

Forty-eight bird species have been recorded in Reach 4 (Appendix E). From this list, ten are threatened and five of these are protected by various international migratory bird agreements with Japan, China and the Republic of Korea (Table 4). Except for the Brown Treecreeper, all other significant bird species listed for Reach 4 are recognised as water or flood-dependant (DNRE 2002; Marchant & Higgins 1990, 1993; VEAC 2008).

Table 4: Significant bird species recorded in Reach 4 of the Loddon River

Common Name	Scientific Name	International Agreements	EPBC	FFG	VROTS
Brown Treecreeper	*Climacteris picumnus*				NT
Common Greenshank	*Tringa nebularia*	J/C/R/B			
Great Egret	*Ardea alba*	J/C		L	VU
Intermediate Egret	*Ardea intermedia*			L	CR
Latham's Snipe	*Gallinago hardwickii*	J/C/R/B			NT
Magpie Goose					VU
Marsh Sandpiper	*Tringa stagnatilis*	J/C/R/B			
Royal Spoonbill	*Platalea regia*				VU
Sharp-tailed Sandpiper	*Calidris acuminata*	J/C/R/B			
Whiskered Tern	*Chlidonias hybridus*				NT

Conservation Status:

- J/C/R/B: JAMBA/CAMBA/ROKAMBA/Bonn international agreements
- FFG listing: L – listed as threatened
- VROTS: CR - Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened (DSE 2007)

Source: (DSE 2009b)

5.1.2. Flora

The pre-1750 and 2005 EVC layers (100 metre buffer from the waterway) reveal that the most dominant EVCs are Grassy Riverine Forest/Riverine Swamp Forest Complex and Floodplain Riparian Woodland (Table 5). Both of these EVCs are considered to be flood-dependent (VEAC 2008).

Table 5: EVCs at Loddon River Reach 4

EVC No.	EVC Name	Conservation Status[1]	pre-1750 (ha)[2]	2005 (ha)[2]
829	Chenopod Grassland	Endangered	24.6	5
56	Floodplain Riparian Woodland	Vulnerable	640	527
812	Grassy Riverine Forest/Riverine Swamp Forest Complex	Depleted	808	576
104	Lignum Swamp	Vulnerable	145	61
823	Lignum Swampy Woodland	Vulnerable	186	124
943	Lignum Swampy Woodland/Plains Grassland Mosaic	Endangered	52	21
132	Plains Grassland	Endangered	193	62
803	Plains Woodland	Endangered	88	37
295	Riverine Grassy Woodland	Vulnerable	14	4
946	Riverine Swampy Woodland/Lignum Swamp Mosaic	Vulnerable	313	132

Note 1: Victorian Conservation status
Note 2: Modelled EVC information pre 1750 and 2005 within Loddon River Reach 4.
Source: (DSE 2009c and 2009d)

The prolonged dry conditions have enabled riparian and wetland species to colonise into the channel (e.g. Common Reed (*Phragmites australis*) and, in some places, young River Red Gum (*Eucalyptus camaldulensis*)). Mature River Red Gum forms a canopy layer on the banks, but there is a general absence of a shrub layer and the ground layer is mostly grasses, including exotics. Large amounts of leaf litter occur on the benches (SKM 2010b).

No flora species listed under the *EPBC Act* have been recorded in Reach 4 of the Loddon River. However a number of species threatened within Victoria have been recorded and one species is listed under the FFG Act (Table 6).

Five of the threatened flora species are considered to be flood-dependant (VEAC 2008), but Dark Roly-poly and Tough Scurf-pea are not.

Table 6: Significant flora species at Loddon River Reach 4

Common Name	Scientific Name	EPBC	FFG	VROTS
Bluish Raspwort	*Haloragis glauca f. glauca*			k
Dark Roly-poly	*Sclerolaena muricata var. semiglabra*			k
Pale Spike-sedge	*Eleocharis pallens*			k
Riverine Flax-lily	*Dianella porracea*			v
Swamp Buttercup	*Ranunculus undosus*			v
Tough Scurf-pea	*Cullen tenax*		L	e
Twin-leaf Bedstraw	*Asperula gemella*			r

Conservation Status:
- VROTS: v- vulnerable in Victoria, r - rare in Victoria, k – poorly known in Victoria (DSE 2005b)
- L = listed under the *Flora and Fauna Guarantee Act 1988*

Source: (DSE 2009e)

5.1.3. Environmental Flow Recommendations

The environmental flow recommendations (Section 3, SKM 2010c) for this reach are summarised in Table 7 below. Appendix D provides a summary of the method used to determine the environmental flow recommendations and how they relate to particular species and environmental values.

The first three priority flow components aim to maintain and enhance River Red Gum recruitment on the bank of the Loddon River and along flood runners that extend onto the floodplain. As each priority flow component is achieved permanent pools will be restored in this reach, with summer low flows and freshes recommended to maintain these refuge areas for aquatic biota (e.g. maintaining water quality).

Table 7: Reach 4a environmental flow recommendations (SKM 2010b)

Season and component*	Magnitude/Duration/Frequency	Justification
Reach 4a		
Spring: High-bank-full	3500 ML/day 3-5 times per decade, duration 6-14 days	**Geomorphology** • Maintain benches, scour pools and entrain organic matter within the Loddon River • Engage numerous distributary channels (e.g. Venables and Kinypanial creeks) **Vegetation:** • Maintain River Red Gum populations
Winter: Low flow	100 ML/day	**Vegetation:** • Inundate low lying benches (manage terrestrial plant encroachment) **Water Quality** • Flush organic material (reduce likelihood of blackwater events in summer)
Spring: freshes	750 ML/day 1 per year (Sept - Dec), duration 10-14 days	**Geomorphology** • Maintain benches higher in the channel **Vegetation:** • Water riparian vegetation • Support significant vegetation (e.g. Spiny Mud-grass *Pseudoraphis spinescens)* **Water Quality** • Flush organic material (further reduce likelihood of blackwater events in summer)
Summer: freshes *Provision: requires above flow components to be delivered*	100 ML/day 2 times per year, duration 10-14 days	**Aquatic Biota** • Maintain permanent pools **Water Quality** • Maintain water quality in permanent pools
Summer: low flow *Provision: should only be delivered if flows described above have already been passed.*	25 ML/day	**Aquatic Biota** • Maintain permanent pools **Water Quality** • Maintain water quality in permanent pools

* Please note: The recommendations for summer freshes and low flows should only be implemented if Winter and Spring flows have been delivered.

5.2. Twelve Mile Creek

5.2.1. Fauna

No data record exists for fauna on this waterway. Due to its connectivity with the Loddon River, it is assumed that the fauna recorded for Reach 4 is representative of the fauna in Twelve Mile Creek (refer to Section 5.1.1).

5.2.2. Vegetation

The stream sides of Twelve Mile Creek and the Loddon River are still vegetated, but with a markedly reduced band of Grassy Riverine Forest/Riverine Swamp complex (Table 8). Along Venables Creek, the band of Lignum Swampy Woodland has also substantially reduced (SKM 2010b).

All but one of the EVCs listed for Twelve Mile Creek are considered to be flood-dependant (VEAC 2008); Chenopod Grassland is not.

Table 8: EVCs at Twelve Mile Creek

EVC No.	EVC Name	Bioregional Conservation Status	pre-1750[1] (ha)	2005[1] (ha)
56	Floodplain Riparian Woodland	Vulnerable	1.3	1.3
104	Lignum Swamp	Vulnerable	108	60
295	Riverine Grassy Woodland	Vulnerable	18	6
812	Grassy Riverine Forest/Riverine Swamp Forest Complex	Depleted	88	77
829	Chenopod Grassland	Endangered	7.5	7
946	Riverine Swampy Woodland/Lignum Swamp Mosaic	Vulnerable	5	1.6

Note 1: Modelled EVC information pre 1750 and 2005 within Loddon River Reach 5.
Source: (DSE 2009c and 2009d)

No flora species listed under the *EPBC Act 1999* have been recorded in Twelve Mile Creek. However, a number of species are present (in common with Reach 4) which are threatened within Victoria (Table 9). All of these species are flood-dependant (VEAC 2008).

Table 9: Significant flora species at Twelve Mile Creek

Common Name	Scientific Name	EPBC	FFG	VROTS
Bluish Raspwort	*Haloragis glauca f. glauca*			k
Pale Spike-sedge	*Eleocharis pallens*			k
Swamp Buttercup	*Ranunculus undosus*			v
Twin-leaf Bedstraw	*Asperula gemella*			r

Conservation Status:
- VROTS: v- vulnerable in Victoria, r - rare in Victoria, k – poorly known in Victoria (DSE 2005)

Source: (DSE 2009b)

5.2.3. Environmental Flow Recommendations

The environmental flow recommendations for this reach are summarised in Table 10 below. Appendix D provides a summary of the method used to determine the environmental flow recommendations and how they relate to particular species and environmental values.

The objectives and flow recommendations are generally the same as for Reach 4a after allowing for transmission losses. Delivering flow through this anabranch will help to maintain the condition of the existing riparian vegetation and enhance recruitment of native riparian species.

Table 10: Twelve Mile Creek environmental flow recommendations (SKM 2010c)

Season and component*	Magnitude/Duration/Frequency	Justification
Reach 4b: Twelve Mile Creek		
Spring: High-bank-full	1200 ML/day 3-5 times per decade, duration 6-14 days	**Geomorphology** • Wet/fill anabranches and flood runners **Vegetation:** • Maintain condition of riparian vegetation • Enhance recruitment of native riparian species
Winter: Low flow**	45 ML/day	**Vegetation:** • Inundate low lying benches (manage terrestrial plant encroachment) • Water roots of mature trees in the riparian zone
Spring: freshes**	300 ML/day 1 per year (Sept - Dec), duration 10-14 days	**Vegetation:** • Wet low lying anabranch cannels and water stands of Moira Grass **Water Quality** • Flush dirty (acidic) water from further instream
Summer: freshes** *Provision: requires above flow components to be delivered*	45 ML/day 2 times per year, duration 10-14 days	**Aquatic Biota** • Maintain permanent pools **Water Quality** • Flush any poor water quality through the system • Maintain water quality in permanent pools
Summer: low flow** *Provision: should only be delivered if flows described above have already been passed.*	10 ML/day	**Aquatic Biota** • Maintain permanent pools **Water Quality** • Maintain water quality in permanent pools

* Please note: The above environmental flow recommendations have been listed in order of priority and reliant on the above flow recommendation being met,

**There is a preference for the flow components recommended for Reach 4a to pass down the Twelve Mile Creek rather than the Loddon River (SKM 2010, p42). Note any changes to environmental flow recommendations would need to be considered when the Loddon River EWR BE is reviewed.

5.3. Reach 5

5.3.1. Fauna

Eight native fish species have been recorded in this section of the Loddon River (Appendix E). Of the native fish species, one (Murray Cod) is listed under the federal *EPBC Act 1999,* three are considered migratory, four are listed for protection under the Victorian *FFG Act 1988*, and three are threatened in Victoria (Table 11). Golden Perch are stocked at Kerang Weir (DPI 2009).

Table 11: Significant fish species recorded in Reach 5 of the Loddon River

Common Name	Scientific Name	EPBC	FFG	VROTS
Golden Perch*	*Macquaria ambigua*			VU
Murray Cod*	*Maccullochella peelii peelii*	VU	L	EN
Silver Perch*	*Bidyanus bidyanus*		L	CR
Murray-Darling Rainbowfish	*Melanotaenia fluviatilis*		L	DD
Unspecked Hardyhead	*Craterocephalus stermuscuscarum fulvus*		L	DD

Conservation Status:

- *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999* Listed: VU – Vulnerable
- FFG listing: L – listed as threatened
- Victorian Rare or threatened Species (VROTS): EN – Endangered, CR – Critical, VU – Vulnerable, DD – Data Deficient (DSE 2007)
- * Migratory

Source: (DSE 2009b)

As part of the Victorian Biological Assessment Program three sites in Reach 5 of the Loddon River are monitored for macroinvertebrates. Lowland communities have been recorded featuring a lower diversity of species than would naturally be expected (EPA 2008).

Forty-nine bird species have been recorded in the lower Loddon River (Appendix E). From this list, three species are listed for protection under the *FFG Act 1988* and one is protected by international migratory bird agreements with Japan and China (Table 12).

Table 12: Significant bird species recorded in Reach 5 of the Loddon River

Common Name	Scientific Name	International Agreements	EPBC	FFG	VROTS
Bush Stone-curlew	*Burhinus grallarius*			L	EN
Great Egret	*Ardea alba*	J/C		L	VU
Grey-crowned Babbler	*Pomatostomus temporalis*			L	EN
Nankeen Night Heron	*Nycticorax caledonicus*				NT
Royal Spoonbill	*Platalea regia*				VU

Conservation Status:

- J/C/R/B: JAMBA/CAMBA/ROKAMBA/Bonn international agreements
- FFG listing: L – listed as threatened
- VROTS: EN – Endangered, VU – Vulnerable, NT – Near Threatened (DSE 2007)

Source: (DSE 2009b)

5.3.2. Flora

Prior to European settlement, according to pre-1750 EVC mapping, vegetation communities in the northern floodplain area were characterised by River Red Gum and Black Box (*Eucalyptus largiflorens*) above a shrub layer of wattle, lignum and saltbush (NCCMA 2003).

Reach 5 of the Loddon River falls mainly within the Murray Fans Bioregion with a small portion upstream within the Victorian Riverina Bioregion (Table 13). The predominant EVCs, including Lignum Swampy Woodland and Grassy Riverine Forest/Riverine Swamp Forest Complex, occur within flood-prone areas. The remainder of EVCs occur in slightly more elevated areas and are less prone to flooding. The understorey consists of grasses, herbs and small shrubs (DSE 2004).

Table 13: EVCs at Loddon River Reach 5

EVC No.	EVC Name	Bioregional Conservation Status		pre-1750[1] (ha)	2005[1] (ha)
		Victorian Riverina	Murray Fans		
829	Chenopod Grassland	-	Endangered	1	1
946	Grassy Riverine Forest/Riverine Swamp Forest Complex	-	Depleted	217	178
823	Lignum Swampy Woodland	Vulnerable	Vulnerable	434	236
103	Riverine Chenopod Woodland	-	Endangered	354	149
295	Riverine Grassy Woodland	-	Vulnerable	85	49
97	Semi-arid Woodland	-	Endangered	<1	<1

Note 1: Modelled EVC information pre 1750 and 2005 within Loddon River Reach 5.
Source: (DSE 2009c and 2009d)

No flora species listed under the *EPBC Act* or the *FFG Act* have been recorded in Reach 5 of the Loddon River. However a number of species threatened within Victoria have been recorded (Table 14).

All of the threatened flora species listed for Reach 5 are considered to be flood (or wetland) dependant (DNRE 2002; VEAC 2008).

Table 14: Significant flora species at Loddon River Reach 5

Common Name	Scientific Name	EPBC	FFG	VROTS
Black Roly-poly	*Sclerolaena muricata var. muricata*			k
Bluish Raspwort	*Haloragis glauca f. glauca*			k
Cane Grass	*Eragrostis australasica*			v
Spreading Emu-bush	*Eremophila divaricata subsp. divaricata*			r
Twin-leaf Bedstraw	*Asperula gemella*			r
Wetland Blown-grass	*Lachnagrostis filiformis* var.2			k
Conservation Status: • VROTS: v- vulnerable in Victoria, r - rare in Victoria, k – poorly known in Victoria (DSE 2005b)				

Source: (DSE 2009e)

5.3.3. Environmental Flow Recommendations

The main environmental flow objectives for this reach are to rehabilitate and maintain the native fish community and other aquatic biota. Summer low-flows and freshes will maintain water quality and habitat for native fish, allow fish passage and provide water for aquatic plants. Higher flow components aim to inundate low lying benches and islands, scour sediment, maintain channel capacity and water key riparian species such as River Red Gum, Black Box and Tangled Lignum.

The specific environmental flow recommendations for this reach are summarised in Table 15. Appendix D provides a summary of the method used to determine the environmental flow recommendations and how they relate to particular species and environmental values.

Table 15: Reach 5 environmental flow recommendations (SKM 2010c)

Season and component*	Magnitude/Duration/Frequency	Justification
Reach 5a		
Summer: Low flow	30 ML/day (Nov- Apr)	**Aquatic Biota** • Maintain water quality and habitat for native fish • Allow fish passage (max depth 50 cm) • Provide water for aquatic plants **Water Quality** • Maintain water quality in permanent pools for fish
Summer: Fresh	70 ML/day 2 times per year, duration 2-3 days	**Vegetation** • Maintain plant community mosaics at various elevations on the river bank **Aquatic Biota** • To allow most native fish to move through the Kerang Weir Fishway.

Season and component*	Magnitude/Duration/Frequency	Justification
Winter: Low flow	70 ML/day May to October	**Vegetation and Geomorphology** • Inundate low lying benches and islands by 5-10 cm. • Prevent further encroachment of *Cumbungi* and Common Reed into the channel. **Aquatic Biota** • Seasonal variation for fish
Spring: High flow	400 ML/day 1 per year (Aug-Sept), duration 5 days	**Aquatic Biota** • Trigger fish movement and spawning, to enhance native fish recruitment and to facilitate fish movement through the Kerang Fishway and into Pyramid Creek and the Kerang Lakes • Timing to trigger Murray Cod migration
Spring: freshes	400 ML/day 1 per year (Oct-Nov), duration 5 days	**Aquatic Biota** • Trigger fish movement and spawning, to enhance native fish recruitment and to facilitate fish movement through the Kerang Fishway and into Pyramid Creek and the Kerang Lakes • Timing in late spring or early summer (preferably in October or November) to trigger movement and enhance recruitment of other native fish species such as Golden Perch and Silver Perch (*Bidyanus bidyanus)*
Spring: Bank-full	2000 ML/day 3-5 times per decade, duration 3-4 days	**Vegetation and Geomorphology** • Scour sediment, maintain channel capacity and water key riparian species such as River Red Gum, Black Box and Tangled Lignum. • Timing of bank-full flows has important implications for riparian vegetation, which are likely to benefit most from events in spring Note: this event could replace one of the spring high flows.
Overbank flow	Not recommended for this reach because levee banks constructed close to the river channel will prevent flows from reaching key floodplain habitats.	

Note 1: All Environmental flow recommendations for Loddon Reach 5 are of equal importance and priority.
Note 2: There are no specific floodplain environmental flow recommendations due to the presence of levees in this reach.

The flow regime in the Loddon River downstream of Barr Creek is influenced by flow in Reach 5a, flow in Barr Creek and back-up flow from the Murray River. Barr Creek Irrigation Drainage Catchment has contributed relatively little flow to the Loddon River since the Lake Tutchewop Salt Interception Scheme was established in 1968. There is no capacity to actively manage flows between Reach 5a and Reach 5b and therefore no separate flow recommendations are made for this reach (SKM 2010c).

6. Hydrology

Historically, flow in the lower Loddon River would have shown a highly seasonal flow pattern with low summer flows and high winter flows with regular floods. River regulation has significantly influenced the lower Loddon River by increasing the magnitude of summer flows, reducing the magnitude of winter flows and reducing the frequency of minor to moderate flooding (LREFSP 2002a).

6.1. Natural water regime

Simulated natural hydrology of the Loddon River has demonstrated a strong seasonal pattern, with:

- low summer flows between November and April
- the lowest flows over January and February
- high winter flows between May and October
- highest flows over August to October.

The high winter flows have historically led to flows frequently occurring in the distributary channels and anabranches (e.g. flow into Twelve Mile Creek in 95% of years) (SKM 2010b). The Sheepwash Creek also provides flood flows from the Loddon River Reach 5 to the Dartagook Forest (Black Box floodplain) (Rob O'Brien, *pers comm.,* 2010).

6.2. Current water regime (pre-NVIRP)

The Loddon River is highly regulated and is used to supply and/or transfer water to the Pyramid-Boort[8] and Torrumbarry[9] Irrigation Areas (40% of stream flow is diverted for consumptive uses) (LREFSP 2002a). It is crossed by the Waranga Western Channel (WWC), which provides water to users in the Loddon basin from the Goulburn basin (DSE 2005a).

Irrigation outfalls currently contribute to flow in the lower Loddon River. These outfalls may provide an artificial flow regime which may have some environmental benefit in the Loddon River. The NVIRP is expected to significantly reduce losses from the Pyramid-Boort and Torrumbarry Irrigation Areas (85% target), which may in turn lead to a number of hydrological changes in the lower Loddon River (NVIRP 2010).

As noted previously, the dry conditions which have persisted in recent years have had a significant impact on the lower Loddon River. Such dry conditions, combined with the impact of river regulation for irrigation, mean that parts of the lower Loddon River between Loddon Weir and Kerang have completely dried in recent years. The current flow regime in the lower Loddon generally reverses the natural seasonal pattern (SKM 2010b).

6.2.1. Reach 4

Flow in the lower Loddon River system can be controlled at Loddon Weir, the Twelve Mile regulator, the Macorna Channel siphon and Kerang Weir. Loddon Weir is primarily used to divert water from the upper Loddon River into the WWC. Releases are not specifically made from Loddon Weir for consumptive use, but there are some irrigation and stock and domestic entitlements between the weir and Macorna Channel (SKM 2010b).

Macorna Channel can carry water from the Murray River, via Kow Swamp to irrigation channels to the west of the Loddon River. The Macorna Channel siphons under the Loddon River at a point approximately 20 km upstream of Kerang, but there is also a regulator that can deliver water directly into the Loddon River (SKM 2010b).

Until the mid 1990s, water was passed through the Macorna channel for long periods of time into the Loddon River to assist with improving water quality in the Kerang Weir Pool for the Kerang Township water supply (R. Stanton, G-MW, *pers comm*., 2010). Most of the outfall from the channel is now due to spills associated with rainfall rejection. The Loddon River downstream of the Macorna Channel is wet most of the time (SKM 2010b).

[8] The section between Loddon Weir and the Macorna Channel is part of the Pyramid-Boort Irrigation Area (supplied from the Goulburn System via Waranga Western Channel).

[9] The section downstream of the Macorna Channel is part of the Torrumbarry Irrigation Area (supplied from the Murray System via National Channel).

Over the flow record period 1976 – 2009, this reach would have had some flow 98% of the time. In recent dry years (post-1997), this has reduced to 96% of the time (SKM 2010b). This section of the river has been experiencing a 'cease to flow' event since May 2007. Prior to the cease to flow event (2006/07), river operations consisted of a pulsed summer low flow consistent with Loddon EWR BE requirements. This flow regime coupled with the high sedimentation of the river bed resulted in the proliferation of Cumbungi and Phragmites at various sites along the reach. The low water allocations in 2007/08 and the Qualification of rights have resulted in no flows passing downstream of the Loddon Weir, although there were minor spills due to the Waranga Western Channel operations.

Winter months have been most severely affected, with average winter flows approximately 7.5% of long-term average and no flows in excess of 420 ML/day. Summer months have been less affected with average summer flows approximately 52% of long-term average. This means that under recent dry conditions the duration of the 'low flow' period has increased and the magnitude of such flows has decreased. There has also been a very significant reduction in the magnitude and/or frequency of high flow events (SKM 2010b).

6.2.2. Twelve Mile Creek

The Twelve Mile Creek regulator is used to control low flows in the Loddon River. The bed of Twelve Mile Creek is lower than the bed of the Loddon River and, without the regulator all water would flow down Twelve Mile Creek during low flows.

Currently the Twelve Mile Regulator consists of a number of drop boards, which historically have remained in place during low flow to direct flows down the Loddon River and during high flows are removed to allow flood flows to pass down both the Loddon River and Twelve Mile Creek.

Prior to 1997, Twelve Mile Creek flowed in most years (95%), predominantly in late winter or early spring, with an average annual flow of approximately 18,000 ML. In recent years (post-1997), dry climate conditions have significantly affected flow in Twelve Mile Creek. The Creek has only flowed in 50% of years since 1997 and significantly, the last flow event in the Creek was in 2004.

6.2.3. Reach 5

Pyramid Creek and Barr Creek are the two significant tributaries that join the lower Loddon River at, or downstream of, Kerang Weir. Pyramid Creek is an enlarged natural carrier that is used to carry irrigation water between Kow Swamp and the Loddon River. Flow from Pyramid Creek joins the Loddon River at Kerang Weir where it can be passed down the Loddon River via Kerang Weir, and delivered to the Kerang Lakes system via Washpen Creek or passed down Sheepwash Creek (SKM 2010b).

Downstream of Kerang Weir, the Loddon River has a similar channel capacity to Pyramid Creek and flows can be dominated by Pyramid Creek flows, particularly during low flow periods. Barr Creek joins the Loddon River approximately two-thirds of the way between Kerang Weir and the River Murray. The Loddon River downstream of the Barr Creek confluence becomes much wider, but flow and water levels in this part of the river are influenced by backwater effects of the River Murray (SKM 2010b) (refer to Figure 3).

Reach 5 of the Loddon River is largely influenced by regulated flows passing over Kerang Weir via the Pyramid Creek, Kow Swamp, National Channel and Torrumbarry Weir as part of the Torrumbarry Irrigation System (TIS).

Under the Murray BE, flows passing over Kerang Weir and any transmission losses from Loddon River Reach 5 are currently accounted for in the G-MW Murray BE.

Previously (during the past 20 years) approximately 100 ML/day has been passed over the Kerang Weir into the lower Loddon River (Reach 5) regardless of irrigation demands downstream. This flow maintained the aquatic values in this reach, however since 2007 extreme drought and the need to save water has meant that flows over the Kerang Weir have largely been reduced to zero unless an irrigation order was received. Figure 4 represents the change in operation of the lower Loddon River in the past two to three years due to drought and low water allocations (NCCMA 2009a).

Over the past three or four years this section of the Loddon River has experienced very low flows, both during summer and winter, and river depths typically less than one metre. When landholders (private diverters who pump directly from the main river channel) place an order for irrigation water, a small flow is released over the Kerang Weir. These more recent low flows are for short periods but have minimal effect on the flows further downstream which can range from having no flow to flows of 5 -10 ML/day.

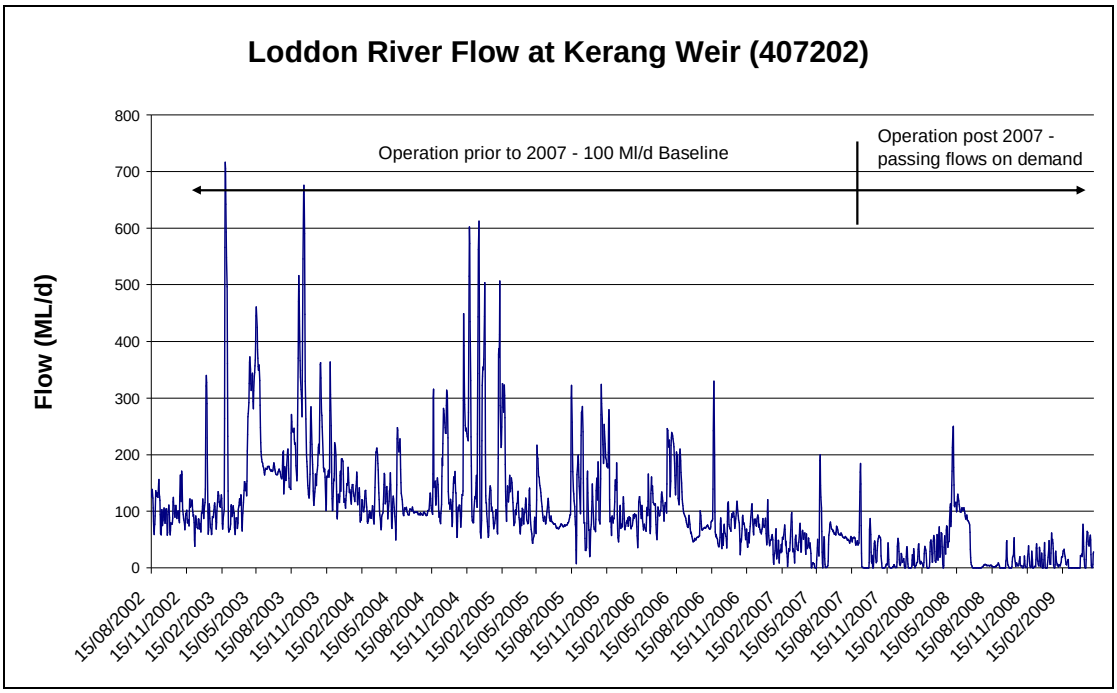

Figure 4: Loddon River flow at Kerang Weir (2002 onwards)

Currently there is no recognised environmental water allocation for the Loddon River downstream of Kerang. During the irrigation season the only flows that are intentionally passed over the Kerang Weir are to service stock and domestic or irrigation needs (NCCMA 2009). Although historically, passing flows of 100ML/day have provided and supported environmental values within the lower Loddon River.

7. NVIRP impact assessment

Irrigation outfalls currently contribute to flow in the lower Loddon River. These outfalls (Table 16) may contribute to a modified flow regime which may be beneficial for some water dependent values identified in Section 5).

To quantify the contribution of irrigation outfalls on flow along the lower Loddon River, a hydrology impact assessment was undertaken (SKM 2010d) which included:

- determining the magnitude and pattern of irrigation outfalls to the lower Loddon River, based on available records of irrigation outfalls
- quantifying the magnitude and pattern of change in outfalls to the lower Loddon River due to reduced outfalls
- assessing the impact of the reduction in outfalls on flow in the lower Loddon River.

The outcomes of this investigation are presented in section 7.3 and have been used to inform the mitigation water assessment (Section 8).

7.1. Loddon River outfall sites

Channel outfalls that result from operation of the system and that directly or indirectly outfall to the Loddon River have been identified and are presented in Table 16 and Figure 5.

Table 16: Location of Loddon River outfalls that will be impacted by the NVIRP (SKM 2010d and NCCMA 2009a)

Outfall	Irrigation area	Road Reference	Connection
Twelve Mile Creek			
No 2/1/1/12 ST009806	Pyramid-Boort	Upstream of Canary Island Rd	Outfalls from the No. 2/1/1/12 channel to the top of 12 Mile Creek (~ 12 km from the Loddon)
No. 1/1/12 ST009820	Pyramid-Boort	Approx. halfway down the creek	Outfalls from the No. 1/1/12 channel approximately half way down 12 Mile Creek (~7 km from the Loddon)
Loddon River Reach 4			
No. 2 ST047427	Pyramid-Boort	Upstream Bennetts (off Loddon River Rd)	Outfalls from the No. 2 channel direct to the Loddon River via a short drain (~0.5 km)
No. 2 ST023234	Pyramid-Boort	Caldwells Rd	Outfalls from the No. 9/2 channel direct to the Loddon River
No. 2 Spur ST023628	Pyramid-Boort	Delamare Lane	Outfalls from the bottom of the No. 2 Spur Channel to a short drain (~ 1 km) then a creek (Sheepwash ~ 0.5 km)
No. 1/9/2 ST023230	Pyramid-Boort	Delamare Lane	Outfalls from the No. 1/9/2 channel direct to the Loddon River via a short drain (~0.5 km)
No. 9/2 ST025135	Pyramid-Boort	Upstream of Macorna Main Channel	Outfalls from the No. 9/2 channel to a drain (~1 km) then to the Loddon River near the Macorna channel outfall
No 3/2/8/2 ST023738	Pyramid-Boort	Upstream of Macorna Main (downstream of Gilmour Lane)	Outfalls from the No. 3/2/8/2 channel to a short drain/creek system (~1 km) before flowing into the Loddon River
Loddon River Reach 5[1]			
No. 1 McKnight ST001704	Torrumbarry	Off Kerang-Murrabit Rd - McKnight	Outfalls to a drain (~1.5 km) (large drain with a few siphons) then to the river
No. 6 McKnight ST001744	Torrumbarry	Off Kerang-Murrabit Rd - McKnight	Outfalls directly to the Loddon River from the No. 6 channel
No. 6 Heffer ST001756	Torrumbarry	Heffer Rd	Outfalls directly to the Loddon River from the bottom of the No. 6 channel
No. 7/1/7 ST011251	Torrumbarry	McKerrow Rd	Outfalls directly to the Loddon River from the No. 7/1/7.
No. 1/7 ST011243	Torrumbarry	near Winlaton Rd	Outfalls directly to the Loddon River from the No. 1/7 channel
No. 4 ST002302	Torrumbarry	Benjaroop-Lake Charm Rd	Outfalls directly to the Loddon River from the bottom of the No. 4 channel

Note 1: Flows from a further Torrumbarry regulator structure (TO901) that can pass water into the Loddon River, located at the Macorna Channel siphon in Loddon River Reach 4, are not expected to be impacted by NVIRP and are not considered in this EWP. If NVIRP seeks to claim water savings from this structure in the future, the requirement for mitigation water would need to be assessed.

The contribution of channel outfalls at each individual site (Appendix F) is considered to be low. This is mainly due to the variable nature of outfalls and the Loddon River outfall sites being hydrologically connected. Therefore the outfalls have been cumulatively assessed for each reach (refer to Section 7.3). Refer to appendix F for waterway outfall site descriptions.

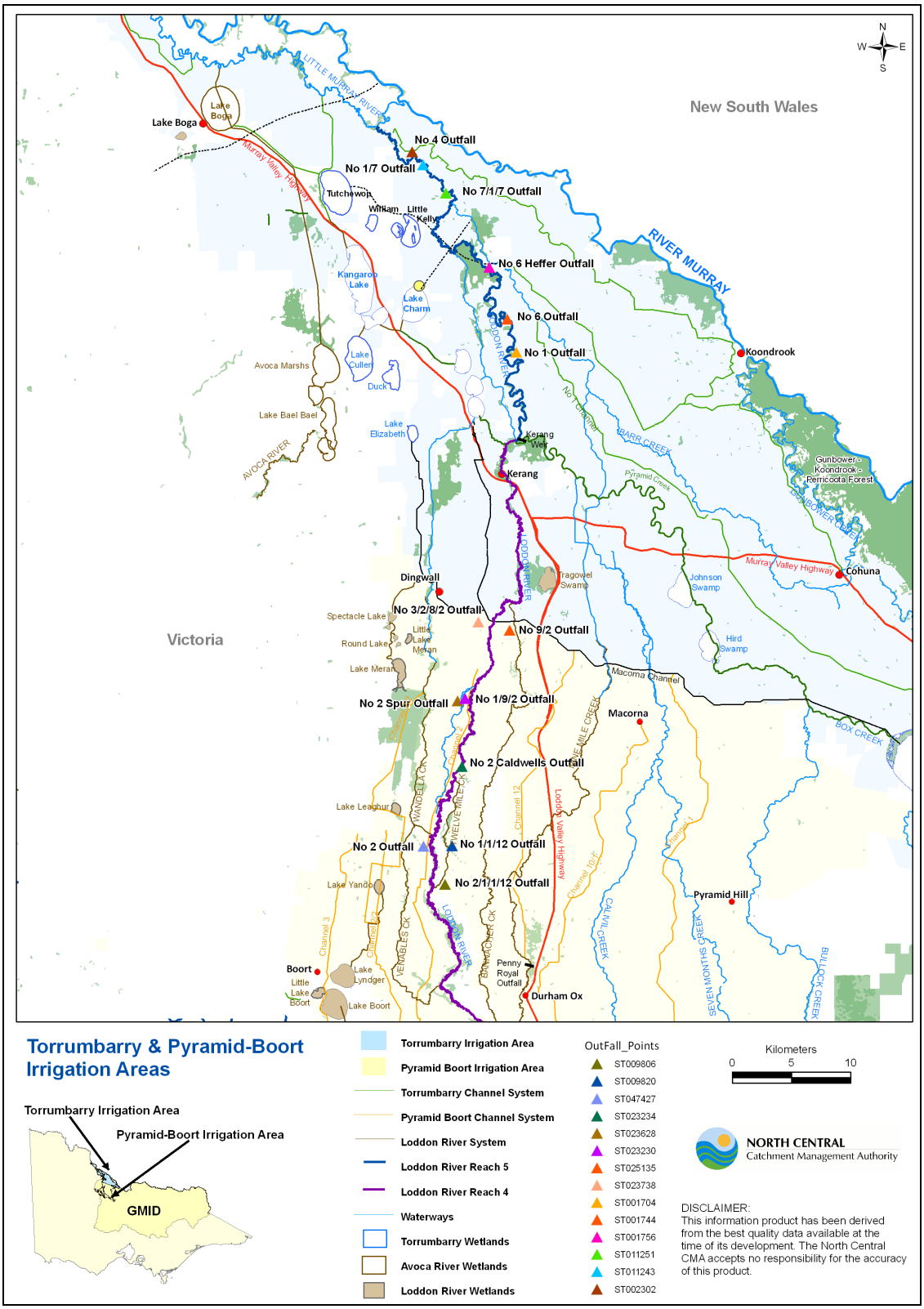

Figure 5: Lower Loddon River outfall locations

NVIRP anticipates that 40 outfalls to Barr Creek may be affected by NVIRP. These outfalls (listed in SKM 2010d) are all located upstream of the Barr Creek salt interception scheme. For this investigation, it has been assumed that outfalls to Barr Creek upstream of the interception scheme would have, and will continue to be, diverted, not reaching the Loddon River. As such, reducing these outfalls is not expected to impact the Loddon River (SKM 2010d).

For the 2004/05 baseline year the total outfall volume for Loddon River Reach 4, Twelve Mile Creek and Loddon River Reach 5 was 752 ML, 85 ML and 1861 ML respectively, refer to Appendix E.

7.1.1. Outfall losses

The indicative loss is the proportion of the outfall volume which is lost between the outfall site and the Loddon River. The indicative loss has been estimated from a desktop review of the outfall location and destination and is not based on measurements or site inspections. Estimates of indicative losses were based on:

- length of drain or creek between the outfall site and the main river channel
- the presence of drainage diversion schemes on the drain or creek
- whether or not the drain or creek would be expected to flow under 'average' flow conditions (SKM 2010d).

Actual losses are extremely variable. In the absence of recorded losses, these indicative losses have been adopted for this investigation (Table 17).

Table 17: Indicative losses for Loddon River outfalls (SKM 2010d)

Outfall	Outfall loss assessment[1&2]	2004/05 Outfall Volume (ML)	Indicative loss	2004/05 Estimated Outfall Volume (ML)
Loddon River Reach 4				
No 2/1/1/12[3] ST009806	• This outfall discharges to the 12 Mile Creek, which does not contribute to flow in the Loddon River under low or average flow conditions. Therefore the outfall would make very limited contributions to the river. • The indicative loss was set to 100%.	1	100 %	0
No. 1/1/12[3] ST009820	• The indicative loss was set to 100% for the same reasons as outfall No 2/1/1/12 (ST009806) above.	84	100 %	0
No. 2 ST047427	• Loss calculations for this outfall resulted in a much higher loss rate (30%) than would be expected given the length of channel (~0.5 km). • As this outfall experiences similar drainage conditions (over a similar length of drain) as the No 9/2 outfall (ST025135) below, the same indicative loss has been adopted for this outfall.	46	15 %	39
No. 2 ST023234	• Outfall is direct to river, indicative loss set to zero.	493	0 %	493
No. 2 Spur ST023628	• Indicative loss = (1.5 km of channel * 12 ML/year of loss per km of channel) / 33 ML of average outfall for 2004/05 period. • Therefore the indicative loss was set to 50% (with rounding). This is relatively high loss, however it was determined to be appropriate due to the apparent drainage diverters.	46	50 %	23
No. 1/9/2 ST023230	• Indicative loss = (0.4 km of channel * 12 ML/year of loss per km of channel) / 28 ML of average outfall for 2004/05 period • Note: the loss rate for this outfall was reduced because this outfall experiences similar drainage conditions to No. 9/2 outfall (ST025135) except has approximately half the drain length.	17	10 %	15

Outfall	Outfall loss assessment[1&2]	2004/05 Outfall Volume (ML)	Indicative loss	2004/05 Estimated Outfall Volume (ML)
	• Therefore the indicative loss was set to 10% (with rounding).			
No. 9/2 ST025135	• Indicative loss = (1.0 km of channel * 12 ML/year of loss per km of channel) / 93 ML of average outfall for 2004/05 period. • Therefore the indicative loss was set to 15% (with rounding).	60	15 %	51
No 3/2/8/2 ST023738	• Loss calculations for this outfall produced unexpected results (150%) due to the low outfall volume. • As this outfall experiences similar drainage conditions to the outfall No. 2 Spur (ST023628), the same indicative loss was adopted for this outfall.	5	50 %	3
	Sub Total	752		624
Twelve Mile Creek				
No 2/1/1/12 ST009806	• Outfall is direct to creek, indicative loss set to zero.	1	0 %	1
No. 1/1/12 ST009820	• Outfall is direct to creek, indicative loss set to zero.	84	0 %	84
	Sub Total	85		85
Loddon River Reach 5				
No. 1 McKnight ST001704	• Indicative loss = (1.5 km of channel * 12 ML/year of loss per km of channel) / 820 ML of average outfall for 2004/05 period. • Therefore the indicative loss was set to 5% (with rounding <5%).	931	5 %	884
No. 6 McKnight ST001744	• Outfall is direct to river, indicative loss set to zero.	40	0 %	40
No. 6 Heffer ST001756	• Outfall is direct to river, indicative loss set to zero.	21	0 %	21
No. 7/1/7 ST011251	• Outfall is direct to river, indicative loss set to zero.	0	0 %	0
No. 1/7 ST011243	• Outfall is direct to river, indicative loss set to zero.	205	0 %	205
No. 4 ST002302	• Outfall is direct to river, indicative loss set to zero.	664	0 %	664
	Sub Total	1861		1814

Note 1: The loss rate of 12ML/year per km of channel has been used (SKM 2008).

Note 2: The average outfall volume for 2004/05 was based on the average outfalls for the three year period surrounding this year (2003/04, 2004/05 and 2005/06) to allow for annual variations (Appendix F).

Note 3: The No 2/1/1/12 and the No 1/1/12 both directly outfall to the Twelve Mile Creek and no losses have been assumed into Twelve Mile Creek although 100% losses have been assumed for Twelve Mile Creek outfall contribution to the Loddon River Reach 4.

For the 2004/05 baseline year the total estimated outfall volume entering the Loddon River Reach 4, Twelve Mile Creek and Loddon River Reach 5 was 624 ML, 85 ML and 1814 ML respectively.

7.1.2. Streamflow measurement

There is a shortage of streamflow data for the lower Loddon River. Flow in the lower Loddon River is measured at few locations, with little or no measurement of tributary flows. Flow data is measured at two locations suitable for this study (Table 18).

Table 18: Available flow gauging stations throughout the study area

Gauge No.	Gauge Name	Period of Record
407205	Loddon River at Appin South	1946 – Current
407202	Loddon River at Kerang Weir	1959 – Current

Loddon River Reach 4

To quantify the contribution of irrigation outfalls for Loddon River Reach 4, actual stream flow from Gauging Station at Appin South was used to estimate the streamflow reduction in outfalls from Pyramid-Boort Irrigation Area. This site was selected as the most downstream flow gauging station within the assessment area. This site is where a quantitative assessment is possible and where the impact of the outfall reductions would be expected to be felt (SKM 2010d).

Twelve Mile Creek

There are no gauged flow data on the Twelve Mile Creek. The Review of environmental flow requirements for the lower Loddon River systems, Issues Paper (SKM 2009b) has estimated flows passing Twelve Mile Creek based on releases from Loddon Weir and accounting for losses and distributary flows. Estimated flows in Twelve Mile Creek assume that all drop boards are in place during low flows (consistent with current operation). Therefore flows do not begin in Twelve Mile Creek until 170ML/day is passed down the Loddon River, when water would spill over the Twelve Mile Creek Regulator into the Twelve Mile Creek.

This information has been used to ascertain the historic contribution of outfalls to flow in Twelve Mile Creek.

Loddon River Reach 5

To quantify the contribution of irrigation outfalls for Loddon River Reach 5, actual stream flow from Gauging Station at Kerang Weir was used to estimate the streamflow reduction in outfalls from Torrumbarry Irrigation Area only (i.e. upstream changes from Pyramid-Boort outfalls were not considered). Due to the nature of the interaction of the Torrumbarry Irrigation Area with the Loddon River at Kerang Weir, flow changes upstream of the weir in most flow conditions are not directly transmitted downstream of the weir (SKM 2010d).

This assessment site is the most downstream flow gauging station within the assessment region, however it is upstream of all Torrumbarry outfalls. As all outfalls in the Torrumbarry Irrigation Area are downstream of Kerang Weir (except for the Macorna Channel, refer to Section 7.1), it is expected that there would be no change in streamflow due to the reduction in outfalls by NVIRP within the TIA at Kerang Weir. Further downstream, the impact on streamflow would increase, peaking at the magnitude of the impact shown for Kerang Weir downstream of the final outfall (just upstream of the Little Murray River confluence) (SKM 2010d).

7.2. Hydrology modelling

The assessment of the impact of NVIRP on streamflow was undertaken for the long-term, recent (post 2000) and 2004/05 baseline year conditions (SKM 2010d).

Long-term assessment
For the long-term assessment, pre-NVIRP streamflow data was sourced directly from the Goulburn, Broken, Campaspe and Loddon Model (GBCL) (1981 to 2006) model and Kerang Lakes REALM model (1975 to 2009) (SKM 2010d). Regressions were derived for each outfall assessment area using multiple linear regression analysis, based on deliveries to the relevant irrigation supply area, allocation and local climate (rainfall) data. All regressions were developed on a monthly basis based on available total historical outfalls to the relevant irrigation district and then scaled (using annual factors) for the outfalls that will be impacted by NVIRP (SKM 2010d). Post-NVIRP streamflow data was derived:

Post NVIRP Streamflow = Pre NVIRP Streamflow – Reduction in Outfalls

The two streamflow series were compared using flow duration curves and the results are discussed in the Section 7.3.1 and 7.3.3.

Recent conditions assessment
For the recent conditions assessment, pre-NVIRP streamflow data for July 2000 to June 2009 was sourced as recorded historical data. Recorded outfall data was used where available (pre-NVIRP outfalls), with post-NVIRP outfalls set to 15% of the recorded pre-NVIRP outfalls. Post-NVIRP streamflow data was derived as above.

As for the long-term assessment, the two streamflow series were compared using flow duration curves and are discussed in the Section 7.3.1 and 7.3.3.

NVIRP baseline year assessment
Time series plots of pre- and post- NVIRP streamflow and of pre- and post-NVIRP outfalls for the baseline year are assessed in Section 7.3.1 and 7.3.3.

7.2.1. Hydrology modelling limitations and uncertainty

The hydrology assessment (SKM 2010) presented in this report is affected by a number of limitations and sources of uncertainty including:

- the small amount of historical outfall data available (limits the calibration of the regression equations used for the long-term assessment)
- the application of regional scaling factors to scale the regression from the region to the outfalls of interest, which means that whilst the average results can be expected to be reasonably accurate, the results for individual years may be over or underestimated
- the determination of regional scaling factors based on a limited number of years, which may or may not be representative of long-term regional factors
- the lack of information about losses between the outfall site and the main river channel, which means that losses may be over or underestimated

Each of these limitations introduces a source of uncertainty into the assessment, the magnitude of which is very difficult to quantify. It has not been possible to quantify the magnitude of the uncertainty within the scope of this investigation.

Despite this, the assessment has been based on the best available information, and is believed to be fit-for-purpose for developing environmental watering plans for the Loddon River, provided the limitations and uncertainties are considered.

7.3. Water regime (post NVIRP)

The results of the hydrology assessment undertaken as part of the development the Loddon EWP are presented below. The post NVIRP hydrology assessment has largely focused on the impact during the irrigation season (August to April), due to the influence of reduced outfalls over the irrigation season.

7.3.1. Reach 4

Overall, the results show that based on both the long-term and recent conditions assessment, the reduction in Reach 4 outfalls due to NVIRP is expected to have a significant impact on flow over the irrigation season at Appin South (refer to Table 19). Figure 6 illustrates the streamflow reduction for irrigation season months (August to April) at Appin South (SKM 2010d).

Table 19: Percent reduction in flow at Appin South (Reach 4) (pre-NVIRP flow for each percentile also shown)

Flow*	Percent Reduction in Flow for an Equivalent Percentile (Pre-NVIRP Flow- ML/month)			
	All Months		Irrigation Season Months	
	Long Term	Recent	Long Term	Recent
Very low flows (90th Percentile)	100% (210)	0% (0)	100% (210)	0% (0)
Low Flows (75th Percentile)	70% (300)	88% (20)	93% (220)	97% (20)
Median Flows (50th Percentile)	16% (450)	28% (130)	31% (370)	42% (120)
High Flows (25th Percentile)	5% (2,150)	19% (280)	10% (2,070)	29% (270)
Very High Flows (10th Percentile)	1% (17,590)	7% (610)	2% (17,010)	9% (660)

*- the percent reduction in flow for each key percentile is based on the average reduction in flow for percentiles ± 5% of the specified percentile. This is to avoid results being skewed by a single, non-representative change. For example, the change reported for 90th percentile flows is based on the change for flows between the 85th and 95th percentiles.

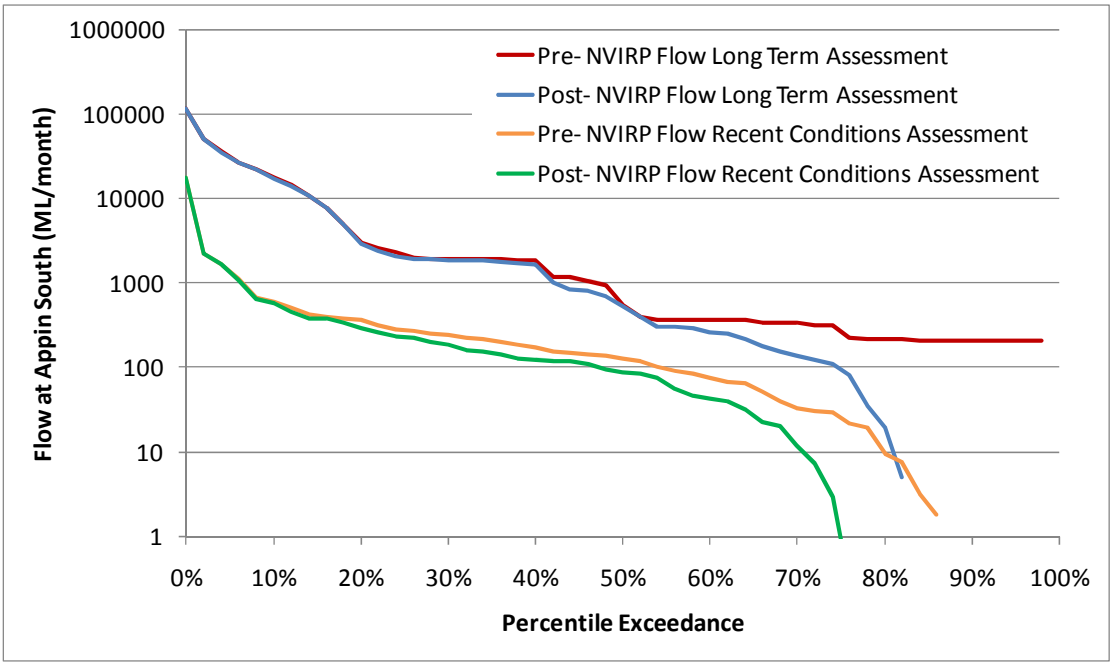

Figure 6: Flow duration curve of pre- and post-NVIRP streamflow for irrigation season months (August to April) at Appin South (Reach 4)

Long-Term Assessment

The long-term assessment indicates that flows over the irrigation season will be affected over the whole flow range. The results indicate that the magnitude of the reduction will be greatest for low flows, with an average reduction in flow for an equivalent percentile of approximately 93% for low flows (75th percentile, 220 ML/month pre-NVIRP) and approximately 31% for median flows (50th percentile, 370 ML/month pre-NVIRP), however high flows are still affected, with an average reduction in flow for an equivalent percentile of approximately 10% (25th percentile, 2070 ML/month pre-NVIRP) (SKM 2010d).

The occurrence of summer cease-to-flow conditions will also be increased by the reduction in outfalls due to NVIRP from 2% of months pre-NVIRP to 22% of months post-NVIRP).

Recent Conditions Assessment

Similar to the long-term assessment, the recent conditions assessment indicates that flows over the irrigation season will be affected over the whole flow range. The magnitude of the reduction will be greatest for low to average flows, with an average reduction in flow of approximately 42% for median flows (50th percentile, 120 ML/month pre-NVIRP), however high flows will still be affected.

The occurrence of summer cease-to-flow conditions will also be increased by the reduction in outfalls due to NVIRP from 14% of months pre-NVIRP to 26% of months post-NVIRP.

Baseline Year Assessment

Figure 7 shows a time series plot of pre- and post- NVIRP flow for the baseline year (2004/05).

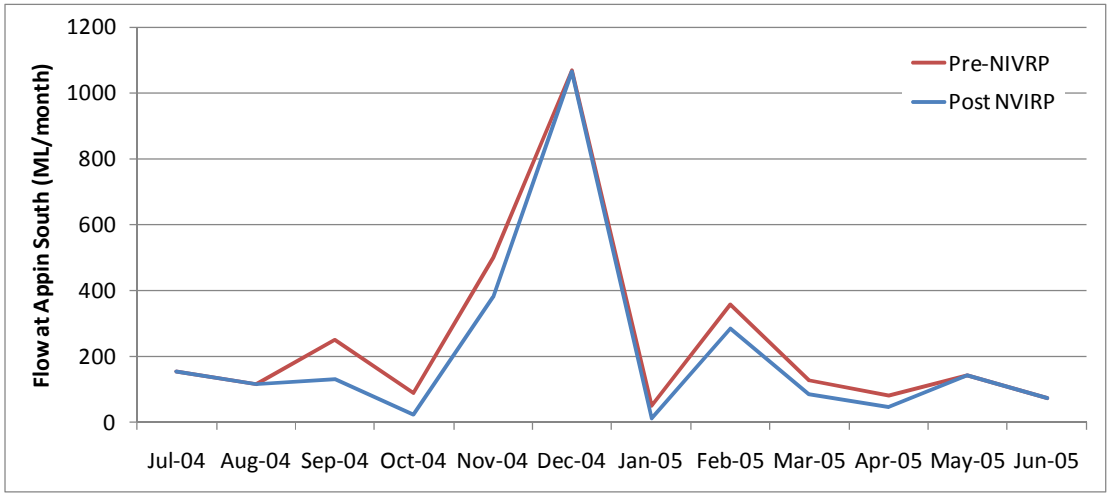

Figure 7: Time series plot of pre- and post-NVIRP flow at Appin South (Reach 4) for 2004/05 (the baseline year) (SKM 2010d).

Figure 8 highlights the significant contribution of channel outfall to the streamflow at Appin South.

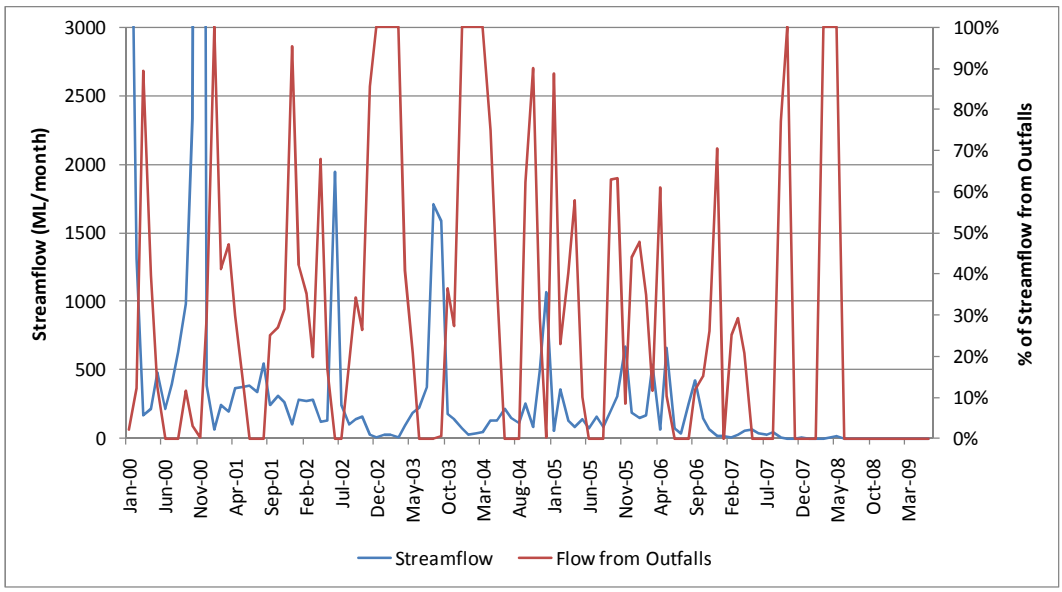

Figure 8: Time series plots showing the proportion of streamflow from outfalls at Loddon River at Appin South.

From the above analysis the reduction in Loddon River Reach 4 outfalls due to NVIRP is expected to lead to a reduction in irrigation season flows at Appin South over the whole flow range.

7.3.2. Twelve Mile Creek

The method for estimating Twelve Mile Creek flow can only be applied for daily data. As such, it has only been possible to assess the impact on NVIRP on streamflow in Twelve Mile Creek for the recent conditions assessment (and the baseline year assessment) which was based on recorded daily streamflow data. The long-term assessments were based on modelled monthly flow data which could not be estimated for Twelve Mile Creek.

Using the information from SKM (2010c) a time series of estimated streamflow for Twelve Mile Creek (at the regulator) has been derived (Refer to Section 7.1.2), and a recent conditions assessment performed (SKM 2010d).

Impact Assessment

Twelve Mile Creek is an intermittent system most often flowing during winter and spring high flow or flood events. Figure 9 shows a time-series plot of estimated historical flow in Twelve Mile Creek at the regulator, this plot shows that Twelve Mile Creek has flowed on seven occasions since July 1998, and last flowed in December 2004.

Historically, Twelve Mile Creek has received occasional, low volume flows from two outfalls over the irrigation season. Figure 10 shows a time-series plot of historical (pre-NVIRP) outfalls to Twelve Mile Creek.

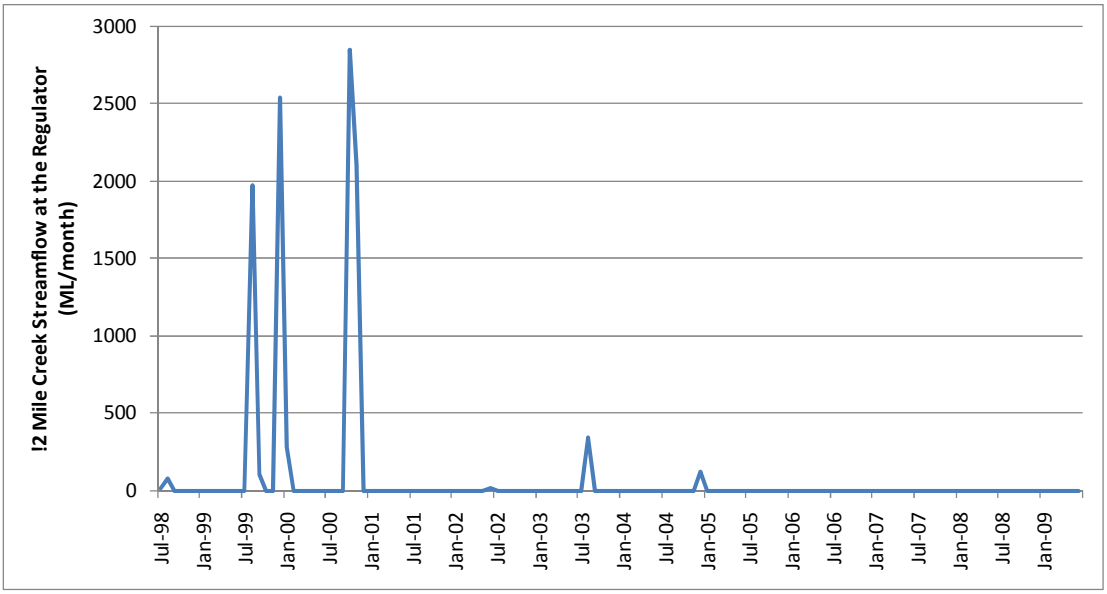

Figure 9: Time-series plot of estimated historical flow in Twelve Mile Creek at the regulator

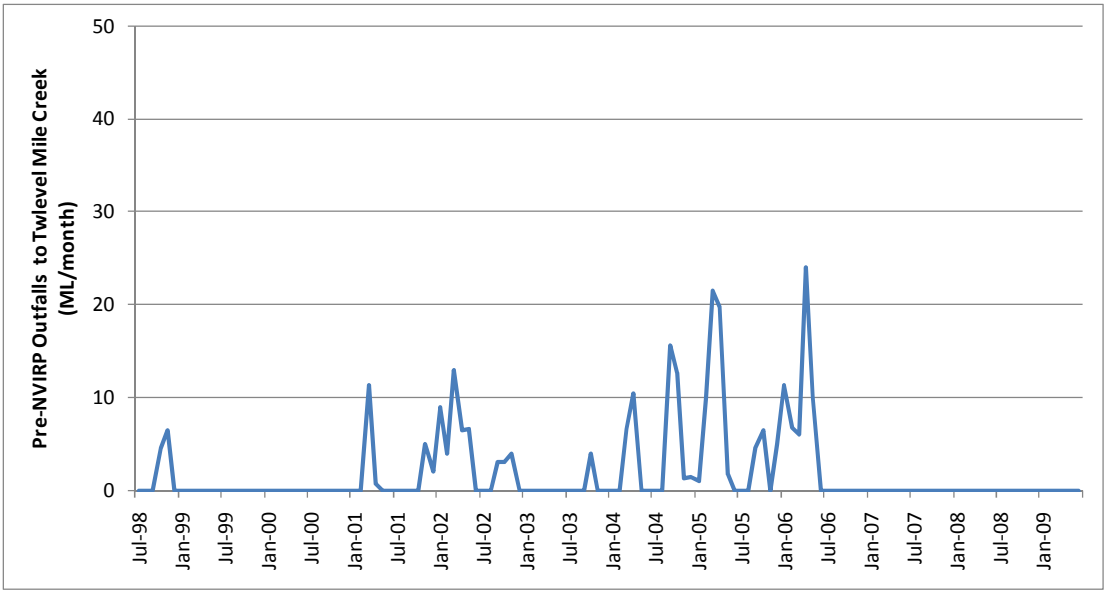

Figure 10: Time series plot of historical (pre-NVIRP) outfalls to Twelve Mile Creek

Due to the timing of flow in Twelve Mile Creek (occasional flow, most often during winter and spring) and outfalls to Twelve Mile Creek (occasional during the irrigation season) the recent record indicates that flow in Twelve Mile Creek would not often be affected by the reduction in outfalls due to NVIRP.

Between July 1998 and June 2009, Twelve Mile Creek is estimated (SKM 2010d) to have flowed on seven occasions for a total duration of eleven months. The historical record indicates Twelve Mile Creek would have received outfalls in only one of these months. In December 2004 Twelve Mile Creek streamflow at the regulator was estimated to be 120 ML, in this month Twelve Mile Creek also received outfalls of 1.4 ML (less than 1% of the pre-NVIRP flow).

Overall the contribution of channel outfalls to the flow in the Twelve Mile Creek is very small.

7.3.3. Reach 5

The results show that based on both the long-term and recent conditions assessment, the reduction in Reach 5 outfalls due to NVIRP is expected to lead to a reduction in flows downstream of Kerang Weir over the irrigation period (refer to Table 20). Figure 11 illustrates the streamflow reduction for irrigation season months (August to April) at Kerang Weir.

Table 20: Percent reduction in flow at Kerang Weir (Reach 5) (pre-NVIRP flow for each percentile also shown)

Flow*	Percent Reduction in Flow for an Equivalent Percentile (Pre-NVIRP Flow- ML/month)			
	All Months		Irrigation Season Months	
	Long Term	Recent	Long Term	Recent
Very low flows (90th Percentile)	6% (3,070)	2% (1,140)	8% (3,080)	2% (1,050)
Low Flows (75th Percentile)	6% (4,250)	3% (2,430)	6% (4,070)	7% (2,490)
Median Flows (50th Percentile)	3% (7,020)	4% (3,570)	4% (6,220)	6% (3,520)
High Flows (25th Percentile)	1% (13,690)	1% (5,600)	2% (12,410)	3% (5,350)
Very High Flows (10th Percentile)	1% (28,450)	2% (8,420)	1% (27,670)	3% (8,170)

*- the percent reduction in flow for each key percentile is based on the average reduction in flow for percentiles ± 5% of the specified percentile. This is to avoid results being skewed by a single, non-representative change. For example, the change reported for 90th percentile flows is based on the change for flows between the 85th and 95th percentiles.

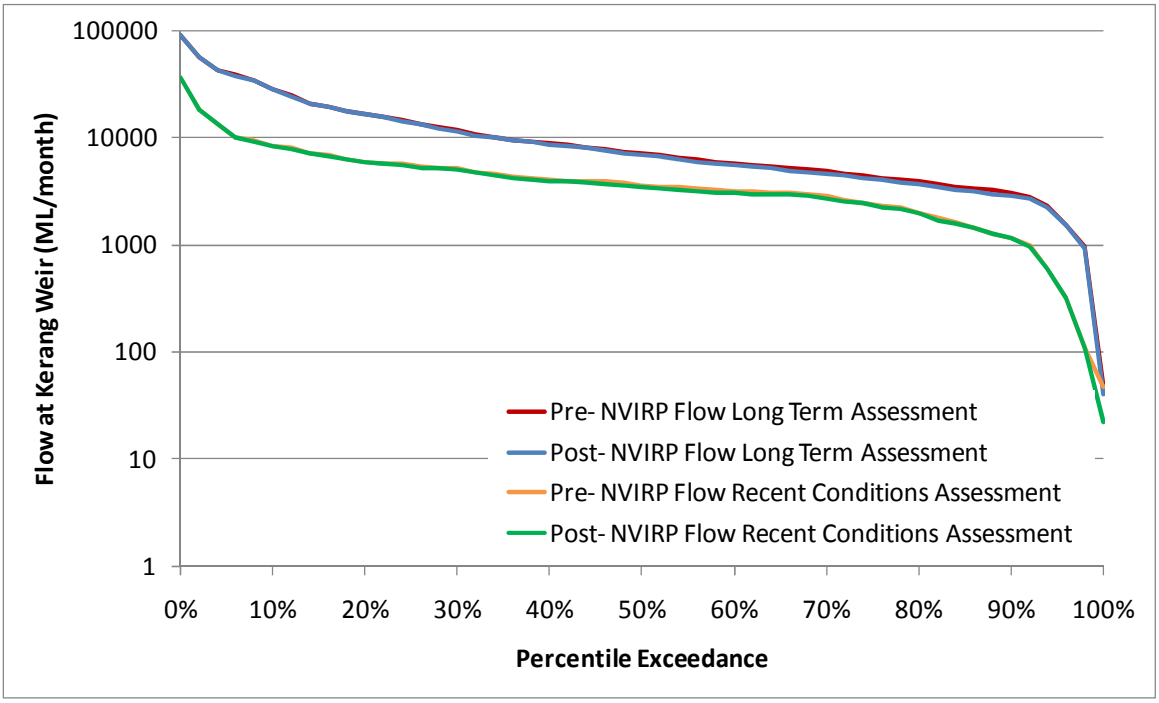

Figure 11: Flow duration curve of pre- and post-NVIRP streamflow for irrigation season months (August to April) at Kerang Weir (Reach 5)

Long-Term Assessment

The long-term assessment indicates that flows over the irrigation period will be affected over the whole flow range. The assessment indicates that low flows will be most affected with a reduction in flow for an equivalent percentile of 8% for very low flows (90th percentile, 3,080 ML/month pre-NVIRP) and 6% for low flows (75th percentile, 4,070 ML/month pre-NVIRP). Higher flows will still be affected, with a reduction in flow for an equivalent percentile of 2% for high flows (25th percentile, 12,410 ML/month pre-NVIRP).

Recent Conditions Assessment

The recent conditions assessment of the impact over the irrigation season (August to April) indicates similar results as the long term assessment, with low flows most affected and higher flows still affected. The results indicate a reduction in flow for an equivalent percentile of 7% for low flows (75th percentile flows, 2,490 ML/month pre-NVIRP) and 3% for high flows (25th percentile flows, 5,350 ML/month pre-NVIRP).

Historically a continual flow of approximately 100 ML/day has been passed over the Kerang Weir year round. It is important to note that since mid-2007 ongoing dry conditions and water saving efforts have meant that this flow is no longer passed and flow is only regulated over Kerang Weir to meet downstream demands.

Baseline Year Assessment

Figure 12 shows a time series plot of pre- and post-NVIRP flow for the baseline year (2004/05).

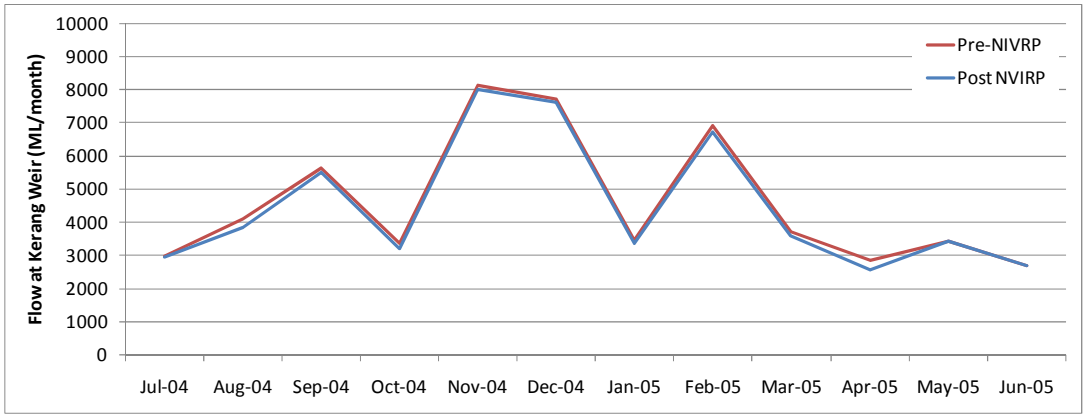

Figure 12: Time series plot of pre- and post-NVIRP flow at Kerang Weir (Reach 5) for 2004/05 (the baseline year) (SKM 2010d)

Figure 13 below indicates the contribution of channel outfalls to streamflow at Kerang Weir. (Note: flow at Kerang Weir is used, as no flow data is available at the bottom of Loddon Reach 5).

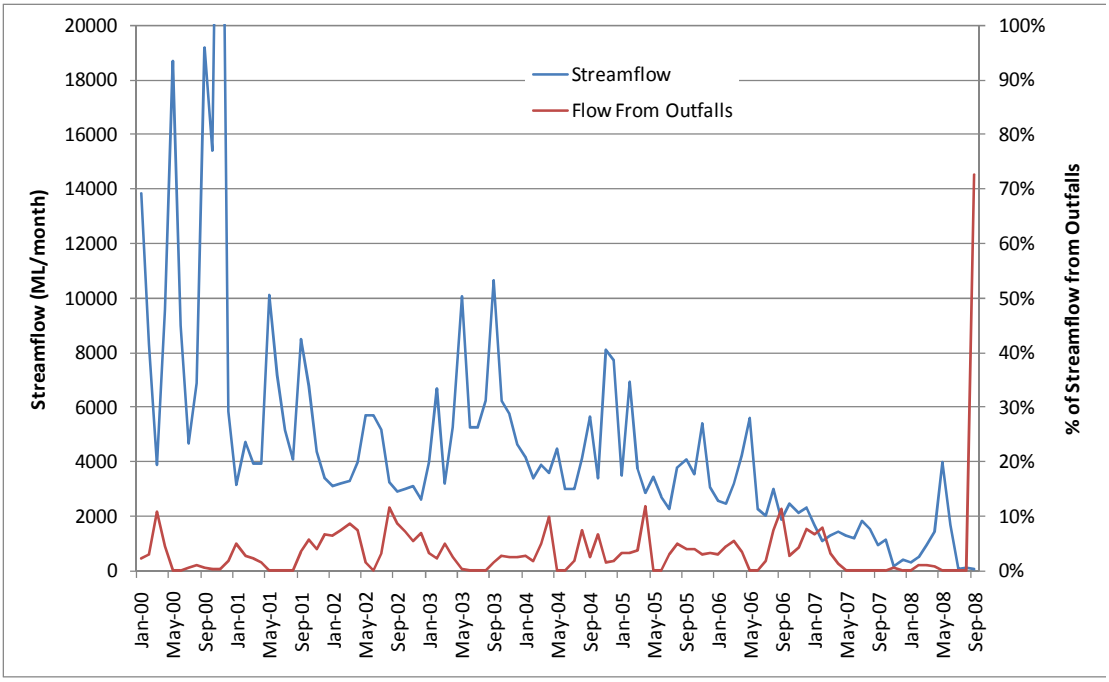

Figure 13: Time series plots showing the proportion of streamflow from outfalls at Loddon River at Kerang Weir.

The reduction in Loddon River Reach 5 outfalls due to NVIRP is expected to lead to a reduction in irrigation season flows downstream of Kerang Weir.

7.3.4. Outfall Pattern Analysis

The TRG highlighted (refer to Appendix G) that it is important to understand how channel outfalls vary over time in order to fully assess the impact that reduced outfalls are likely to have on environmental values. Therefore an analysis was undertaken to better understand the pattern of the outfalls entering Reach 4 and Reach 5 of the Loddon River.

Flow from outfall structures can be due to general operational practice which is generally related to the amount of demand being supplied in a channel system or due to rainfall rejection events which are influenced by the amount of rainfall and the level of demand being supplied in the channel system prior to the rainfall event.

Outfalls which are predominantly demand-driven are most likely to provide a relatively steady contribution to stream flow throughout the year. This type of outfall is most likely to support base (low) flow components of the flow regime. Outfalls which are predominantly driven by rainfall are most likely to provide highly variable contributions to streamflow with a high proportion of the outfall volume occurring in a few short bursts. This type of outfall is more likely to support fresh and high flow components of the flow regime.

The multi-linear regression analysis for channel outfalls (Refer Section 7.2 and SKM 2010d) was used to develop a relationship between irrigation demand, rainfall and irrigation allocation. An outfall pattern analysis using regression analysis information, actual outfalls and rainfall was undertaken. Conclusion from the outfall pattern analysis is:

- The majority of the outfall volume and variation could be explained by irrigation deliveries to the region with climate variables (rainfall) being less influential
- Average weekly outfall volumes ranged from 10.9 ML/wk to 35.3 ML/wk for reach 4 and reach 5 respectively (Refer to Table 21)
- Higher outfall volumes are relatively rare with outfalls exceeding 30ML/wk for Loddon Reach 4 on five occasions. Figure 14 indicates that rainfall exceeded 20mm/wk on four of the 5 occasions (over the 3 years assessed)
- Higher outfall volumes are relatively rare with outfalls exceeding 100ML/wk for Loddon Reach 5 on four occasions. Figure 15 indicates that rainfall exceeded 40mm/wk on two of the 4 occasions (over the 4 years assessed)

- Overall, these results suggest that the outfalls have historically been supporting the base or low flow components of the flow regime at relatively low outfall volumes, and that higher flows are relatively rare.

Table 21: Key statistics for weekly outfalls

Outfall Group	Average Yearly Outfall Volume (ML)	Average Weekly Volume (ML/week)	Median Weekly Volume (ML/week)	Peak Weekly Volume (ML/week)
Outfall to Loddon Reach 4	418	10.9	7.0	78.0
Outfall to Loddon Reach 5	1,649	35.3	28.1	276

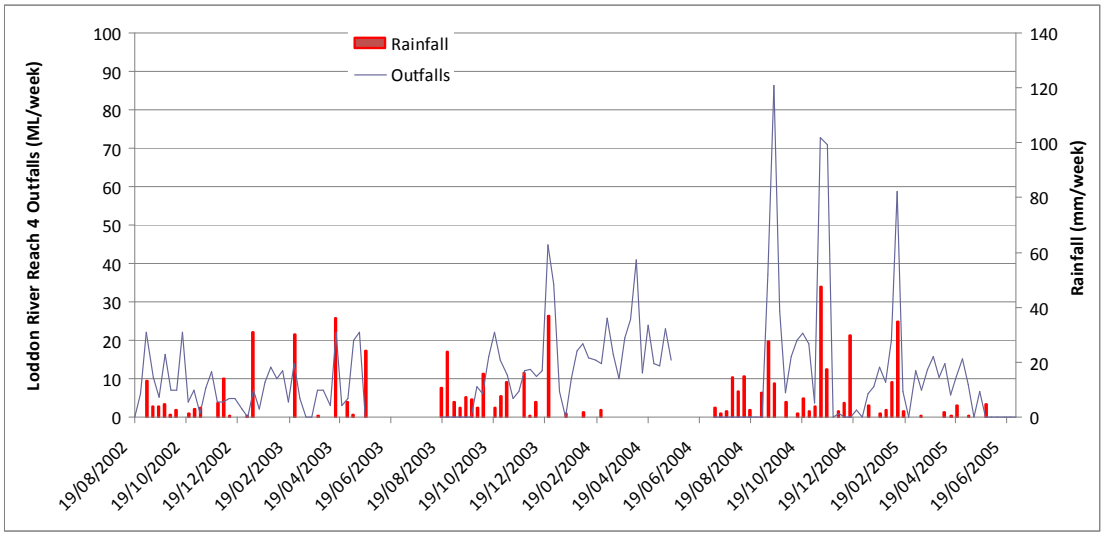

Figure 14: Time series plot of weekly Loddon Reach 4 Channel Outfalls and rainfall

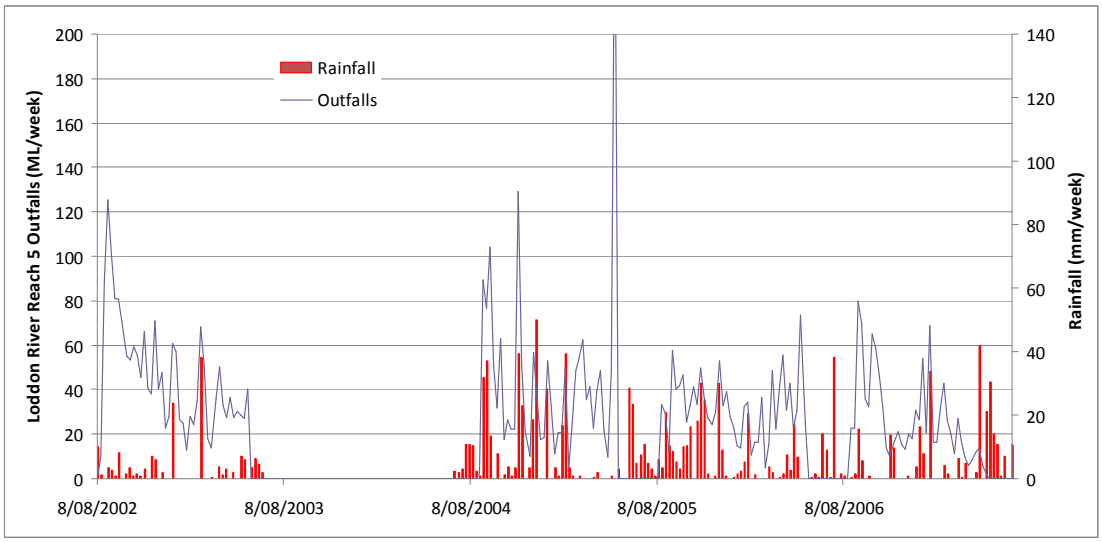

Figure 15: Time series plot of weekly Loddon Reach 5 Channel Outfalls and rainfall

8. Mitigation water assessment

The volume of water that is required to offset the impact of NVIRP on waterways that have become reliant on this water to support high environmental values is termed 'mitigation' water. The potential impact of NVIRP considered in the Loddon River EWP is related mainly to a reduction in outfalls. Other potential impacts to the waterway will be managed through the Water Change Management Framework (NVIRP 2010) and Site Environmental Management Plans.

Guiding principles for mitigation water based on government policy have been defined by the Water Change Management Framework and are:

1. Water savings are the total (gross) volumes saved less the volume of water required to ensure no net impacts due to the project on high environmental values.
2. Using the same baseline year (2004–05) as that used to quantify savings, taking into account the long-term average annual patterns of availability.
3. The mitigation water will be deployed according to the EWP.
4. Sources of mitigation water will be selected to ensure water can be delivered in accordance with the delivery requirements as specified in the EWPs. Water quality will need to be considered for all sources of water to ensure it is appropriate.

In the majority of cases, actual outfall volumes will be less than what is required to support all water-dependent environmental values of a particular waterway. Therefore, the outfall water only forms part of the overall volume required to provide the watering regime of the waterway. The watering regime supports processes and systems which in turn provide suitable conditions for defined ecological values (e.g. spring freshes to cue breeding and migratory movements for native fish). Consequently, the mitigation water will be calculated based on a qualitative assessment supported by data and information on the values that a waterway supports, and the hydrological information available at the time.

A process for calculating mitigation water based on the best available information has been developed and involves the application of a series of steps that includes:

Step 1: Describe the desired environmental flow regime

Step 2: Determine the baseline year incidental water contributions

Step 3: Assess dependency on baseline mitigation water contributions

Step 4: Calculate the annualised baseline mitigation water volume

Step 5: Calculate the mitigation water commitment

Step 6: Calculate the LTCE mitigation water volume

NVIRP have assumed an overall 85 % reduction in channel outfalls across the entire GMID. This has been reflected in the hydrology modelling undertaken for this EWP and is appropriate for assessing system wide impacts. Given the uncertainty in estimating the actual reduction in individual outfalls (i.e. it is expected that each system operator will be aiming to reduce channel outfall to zero) it is appropriate to use 100% reduction in channel outfalls in the mitigation water calculation.

8.1. Reach 4 mitigation water assessment

Step 1: Describe the desired environmental flow regime

The revised environmental flow recommendations for Loddon Reach 4 (Section 5.1.3) provide the desired watering regime required to achieve the ecological objectives. The environmental flow recommendations have been developed using a priority ranking and have taken into account current conditions and the likelihood of being able to deliver water in the future.

Although summer freshes and summer low flows are the lowest priorities as part of the revised recommendations, if water was available and higher priority recommendations could be met then the desired flow regime would include operating the Loddon River Reach 4 as a permanently flowing waterway (i.e. summer freshes and low flows).

Please note: The recent review of environmental flow recommendations for the lower Loddon River indicated that whatever proportion of the flows that were released from Loddon Weir to meet the objectives in Reach 4a should be adequate to meet the environmental requirements near Appin South (SKM 2010c).

Step 2: Determine the baseline year incidental water contribution[10]

This step determines the baseline year incidental water contribution from hydrological connections- outfalls, leakage and seepage. As outlined in Section 1.6, leakage and seepage from NVIRP works is difficult to quantify until works have been implemented[11]. The EWP has assumed that NVIRP works contributing to reduced leakage and seepage is minor and has not been accounted for within the following steps.

Therefore, only one hydrological connection (waterway outfalls) has been included within the mitigation water calculations and the potential contributions from leakage and seepage have been excluded.

The baseline year incidental water contribution is the amount of water received by the waterway from outfalls. The baseline year (2004-05) outfall recorded was 752 ML, the portion of water that reached the waterway equates to 624 ML (refer to Table 22 below SKM 2010d).

Table 22: Determination of the baseline year contribution at Loddon River Reach 4

Hydrological connection or incidental water source (e.g. Outfall #)	Baseline year incidental water at origin (Gross) (ML)	Estimated losses between origin (irrigation system) and waterway (for baseline year) (ML)	Baseline year incidental water contribution at the waterway (Net) (ML)
ST009806	1	1	0
ST009820	84	84	0
ST047427	46	7	39
ST023234	493	0	493
ST0023628	46	23	23
ST023230	17	2	15
ST025135	60	9	51
ST023738	5	3	3
TOTAL	**752 ML/year**	**129 ML/year**	**624 ML/year**

Step 3: Assess dependency on baseline incidental water contributions

The WCMF specifies the criteria to be applied in assessing whether mitigation water is required for a wetland or waterway with high environmental values. These criteria have been assessed for Loddon River Reach 4 with the results presented in Table 23.

[10] Incidental water contributed in the baseline year for each hydrological connection i.e. outfall water, seepage and leakage of a supply channel to the waterway.

[11] If future NVIRP actions are likely to impact the potential for leakage and seepage in Reach 4 (i.e. lining the main supply channel or decommissioning other channels), it is recommended that a more detailed analysis is undertaken.

Table 23: Reach 4 Mitigation water dependency assessment

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
1. Mitigation water may be assessed as not required where:	
1.1 There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway	There is a hydraulic connection, indicative losses have been calculated
1.2 The water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values)	Water reaches the waterway (losses calculated)
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1 That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact)	Desired water regime for Reach 4 is to operate as a permanently flowing stream, therefore outfall water is not surplus.
2.2 That occurs at a time that is detrimental to the environmental values	Desired water regime for Reach 4 is to operate as a permanently flowing stream, therefore outfall water during the irrigation period is not detrimental to environmental values
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Irrigation water in the Pyramid-Boort Irrigation Area is of good quality, therefore outfall water is not detrimental to environmental values in the Reach 4 (refer to Appendix H)
3. Mitigation water may be assessed as not required where the environmental values:	
3.1 Do not directly benefit from the contribution from the irrigation system (e.g. river red gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	Desired water regime for Reach 4 is to operate as a permanently flowing stream, therefore outfall water is likely to directly benefit and not be detrimental to environmental values.
4. Mitigation water may be assessed as not required where the removal of the contribution from the irrigation system does not:	
4.1 Increase the risk of reducing the environmental values (e.g. outfalls form a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk)	**Increased risk of reducing environmental values including** • **Water quality in permanent pools** • **Murray Cod, Silver and Golden Perch (Refer to 'significant impact on environmental values discussion below).**
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system)	**If outfall volumes were reduced, additional EWR water may be required to meet summer base-flow and spring and summer freshes.**

The above assessment demonstrates that the **outfall water provides benefit to Loddon River Reach 4 and that the provision of mitigation water is warranted if it is managed for environmental purposes** due to:

- Flows over the irrigation season will be affected over the whole flow range and particularly the low and average flows.
- The occurrence of summer cease-to-flow conditions will also be increased by the reduction in outfalls due to NVIRP from 2% of months pre-NVIRP to 18% of months post-NVIRP
- The desired flow regime required based on revised environmental flow recommendations is to meet summer fresh and summer base-flows and operate the reach as a permanently flowing stream to maintain aquatic habitat and water quality.
- Significant species including Murray Cod, Silver and Golden Perch are likely to be impacted by a significant reduction in flows including increasing cease to flow from 2% to 18%. Fore example, reduced flows (increased occurrence in cease to flow) will reduce the amount of aquatic habitat, impact on water quality and persistence in permanent pools and therefore impact on fish species.

Step 4: Calculate the annualised baseline mitigation water volume (BMW)

The baseline mitigation water volume is expressed as the baseline incidental water contributions divided by the number of years in the cycle of the desired water regime. Mitigation water is required in the years that Loddon River has an environmental flow recommendation (i.e. summer low flow). When the waterway is in a dry phase, no mitigation water is required.

The desired flow regime for the Loddon River Reach 4 is a permanently flowing stream. Therefore mitigation water is required every year.

Loddon River Reach 4 has multiple incidental water sources, some of which incur losses between the irrigation system and the waterway. These losses can be avoided via delivery of mitigation water from Loddon Weir, therefore the net annualised BMW are calculated below (Table 24).

Table 24: Determination of the baseline year contribution at Loddon River Reach 4

Hydrological connection or incidental water source (e.g. Outfall)	Baseline year incidental water at origin (Gross) (ML)	Baseline year incidental water at waterway (Net) (ML)	Estimated losses between origin (irrigation system) and waterway (for baseline year) (ML)	Annualised baseline mitigation water volume (ML)
ST009806	1	0	1	0
ST009820	84	0	84	0
ST047427	46	39	7	39
ST023234	493	493	0	493
ST0023628	46	23	23	23
ST023230	17	15	2	15
ST025135	60	51	9	51
ST023738	5	3	3	3
TOTAL	**752 ML/year**	**624 ML/year**	**129 ML/year**	**624 ML/year**

The annualised BMW volume for the incidental water source is calculated using the baseline year incidental water contribution at the waterway (Net), as follows:

Net BMW (LR Reach 4 Outfalls 2004-05) = Baseline year incidental water at waterway (Net) (Step 2) / Desired flow regime for Loddon River Reach 4 (Step 1)

$= (0_{(ST009806)} + 0_{(ST009820)} + 39_{(ST047427)} + 493_{(ST023234)} + 23_{(ST0023628)} + 15_{(ST023230)} + 51_{(ST025135)} + 3_{(ST023738)}) / 1$ (every year)

= 624 ML/year

Step 5: Calculate the mitigation water commitment (MWC)

The MWC expresses the BMW (Step 4) as a percentage of the annualised baseline incidental water contribution. It is used to calculate the share of annual water savings. These are calculated each year in accordance with the Water Savings Protocol and the associated Technical Manual and will become available in any following year. The mitigation water commitment has been calculated separately for each identified hydrological connection in Table 25 below.

Table 25: Determination of the mitigation water commitment at Loddon River Reach 4

Hydrological connection or incidental water source (e.g. Outfall #)	Baseline year incidental water contribution at origin (Gross) (ML)	Baseline year incidental water contribution at waterway (Net) (ML)	Annualised baseline mitigation water volume (ML)	Mitigation Water Commitment (%)
ST009806	1	0	0	0%
ST009820	84	0	0	0%
ST047427	46	39	39	85%
ST023234	493	493	493	100%
ST0023628	46	23	23	50%
ST023230	17	15	15	88%
ST025135	60	51	51	90%
ST023738	5	3	3	40%
TOTAL	**752 ML/year**	**624 ML/year**	**624 ML/year**	**83%**

The overall mitigation water commitment for Loddon Reach 4 is 83%.

MW C (%)	= Baseline Mitigation Water $_{\text{(Loddon River Reach 4 2004-05)}}$ (Step 4) Incidental water contributions at origin (Gross) $_{\text{(2004-05)}}$ (Step 2)
	= 624 ML / 752 ML * 100 (permanent watering regime)
	= 0.83 or 83 %

Please note: the above MWC will be applied to the Gross baseline savings in any year to determine the mitigation water for that year.

Step 6: Calculate the LTCE mitigation water volume

The LTCE mitigation water volume is used to account for mitigation water when reporting against the net savings target. This volume is calculated by multiplying the mitigation water commitment (Step 5) by the baseline mitigation water volume (Step 4) and the LTCE conversion factor.

Please note: calculation and confirmation on the LTCE conversion factor is required from DSE. This will be decided at or near the end of the NVIRP.

8.2. Twelve Mile Creek mitigation water assessment

Step 1: Describe the desired environmental flow regime

The environmental flow recommendations for Twelve Mile Creek (Section 5.2.3) provide the desired watering regime required to achieve the ecological objectives. The environmental flow recommendations have been developed using a priority ranking and have taken into account current conditions and the likelihood of being able to deliver water in the future.

The objectives and flow recommendations are generally the same as for Reach 4a after allowing for transmission losses. Therefore the desired flow regime would include operating the Twelve Mile Creek as a permanently flowing waterway (i.e. summer freshes and low flows).

Step 2: Determine the baseline year incidental water contribution[12]

This step determines the baseline year incidental water contribution from hydrological connections- outfalls, leakage and seepage. As outlined in Section 1.6, leakage and seepage from NVIRP works is difficult to quantify until works have been implemented[13]. The EWP has assumed that NVIRP works contributing to reduced leakage and seepage is minor and has not been accounted for within the following steps.

Therefore, only one hydrological connection (waterway outfalls) has been included within the mitigation water calculations and the potential contributions from leakage and seepage have been excluded.

The baseline year incidental water contribution is the amount of water received by the waterway from outfalls. The baseline year (2004-05) outfall recorded was 85 ML, the portion of water that reached the waterway equates to 85 ML (Table 26 and SKM 2010d).

Table 26: Determination of the baseline year contribution at Twelve Mile Creek

Hydrological connection or incidental water source (e.g. Outfall #)	Baseline year incidental water at origin (Gross) (ML)	Estimated losses between origin (irrigation system) and waterway (for baseline year) (ML)	Baseline year incidental water contribution at the waterway (Net) (ML)
ST009806	1	0	1
ST009820	84	0	84
TOTAL	**85 ML/year**	**0 ML/year**	**85 ML/year**

Step 3: Assess dependency on baseline incidental water contributions

The WCMF specifies the criteria to be applied in assessing whether mitigation water is required for a wetland or waterway with high environmental values. These criteria have been assessed for Twelve Mile Creek with the results presented in Table 27.

Table 27: Twelve Mile Creek mitigation water dependency assessment

Criteria by which mitigation water may be assessed as not required	Link between outfall water (losses) and environmental values
1. Mitigation water may be assessed as not required where:	
1.1 There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway	There is a hydraulic connection, indicative losses have been calculated
1.2 The water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values)	Water reaches the waterway (losses calculated)
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1 That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact)	Desired water regime for Twelve Mile is to operate as a permanently flowing stream (Refer Step 1 above & SKM 2010c), therefore outfall water is not surplus.
2.2 That occurs at a time that is detrimental to the	Desired water regime for Twelve Mile

[12] Incidental water contributed in the baseline year for each hydrological connection i.e. outfall water, seepage and leakage of a supply channel to the waterway.

[13] If future NVIRP actions are likely to impact the potential for leakage and seepage in Reach 4 (i.e. lining the main supply channel or decommissioning other channels), it is recommended that a more detailed analysis is undertaken.

environmental values	Creek is to operate as a permanently flowing stream, therefore outfall water is not detrimental to environmental values.
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Irrigation water in the Pyramid-Boort Irrigation Area is of good quality, therefore outfall water is not detrimental to environmental values in the Twelve Mile Creek.
3. Mitigation water may be assessed as not required where the environmental values:	
3.1 Do not directly benefit from the contribution from the irrigation system (e.g. river red gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	Desired water regime for Twelve Mile Creek is to operate as a permanently flowing stream, therefore outfall water is not likely to be detrimental to environmental values.
4. Mitigation water may be assessed as not required where the removal of the contribution from the irrigation system does not:	
4.1 Increase the risk of reducing the environmental values (e.g. outfalls form a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk)	**Outfalls form a very small portion of the water required to met the environmental flow recommendations**
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system)	**The outfall volume is a very small portion of the desired environmental watering regime**

The above assessment demonstrates that the **outfall water <u>does not</u> provide benefit to Twelve Mile Creek.** Therefore **mitigation water is not required to maintain the environmental values of the waterway.**

The assessment process for calculation of mitigation water for Twelve Mile Creek suggests that mitigation water is not required to maintain the environmental values. Due to the low volumes of outfall water in comparison to the volumes required to support the Twelve Mile Creek environmental values. It is reasoned that outfalls are not supporting high environmental values at the waterway and therefore, there is no requirement on NVIRP to provide mitigation water.

Please note: due to the recommendation above Steps 4, 5 and 6 do not need to be calculated.

8.3. Reach 5 mitigation water assessment

Step 1: Describe the desired environmental flow regime

The revised draft environmental flow recommendations are to rehabilitate and maintain the native fish community and other aquatic biota (SKM, 2010c, refer to Section 5.3.3. It also states that all environmental flow recommendations are of equal importance and should be delivered:

1. **Summer low flow** 25 (15-35) ML/day (Nov- Apr)
2. **Summer fresh:** 70 ML/day 2 times per year, duration 2-3 days
3. **Winter low flow:** 70 ML/day May to October
4. **Spring high flow:** 400 ML/day 1 per year (Aug-Sept), duration 5 days
5. **Spring freshes:** 400 ML/day 1 per year (Oct-Nov), duration 5 days

The revised environmental flow recommendations for Loddon Reach 5 (Section 5.3.3) provide the desired flow regime to achieve the ecological objectives. The environmental flow recommendations for Loddon River Reach 5 include maintaining a permanent flow through out the irrigation season (i.e. summer freshes and base-flow).

Step 2: Determine the baseline year incidental water contribution[14]

This step determines the baseline year incidental water contribution from hydrological connections- outfalls, leakage and seepage. As outlined in Section 1.6, leakage and seepage from NVIRP works is difficult to quantify until works have been implemented[15]. The EWP has assumed that NVIRP works contributing to reduced leakage and seepage is minor and has not been accounted for within the following steps.

Therefore, only one hydrological connection (waterway outfalls) has been included within the mitigation water calculations and the potential contributions from leakage and seepage have been excluded.

The baseline year loss contribution is the amount of water received by the waterway from outfalls. The baseline year (2004-05) outfall recorded was 1861 ML, the portion of water that reached the waterway equates to 1814 ML (refer to Table 28 and SKM 2010d).

Table 28: Determination of the baseline year contribution at Loddon River Reach 5

Hydrological connection or incidental water source (e.g. Outfall #)	Baseline year incidental water at origin (Gross) (ML)	Estimated losses between origin (irrigation system) and waterway (for baseline year) (ML)	Baseline year incidental water contribution at the waterway (Net) (ML)
ST001704	931	47	884
ST001744	40	0	40
ST001756	21	0	21
ST011251	0	0	0
ST011243	205	0	205
ST002302	664	0	664
TOTAL	**1861 ML/year**	**47 ML/year**	**1814 ML/year**

Step 3: Assess dependency on baseline incidental water contributions

The WCMF specifies the criteria to be applied in assessing whether mitigation water is required for a wetland or waterway with high environmental values. These criteria have been assessed for Loddon River Reach 5 with the results presented in Table 29.

[14] Incidental water contributed in the baseline year for each hydrological connection i.e. outfall water, seepage and leakage of a supply channel to the waterway.

[15] If future NVIRP actions are likely to impact the potential for leakage and seepage in Reach 4 (i.e. lining the main supply channel or decommissioning other channels), it is recommended that a more detailed analysis is undertaken.

Table 29: Reach 5 Mitigation water dependency assessment

Criteria by which mitigation water may be assessed not required	Link between outfall water (losses) and environmental values
1. Mitigation water may be assessed as zero where:	
1.1 There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway	There is a hydraulic connection, indicative losses have been calculated
1.2 The water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values)	Outfall water reaches waterway (losses have been calculated)
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1 That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact)	Desired water regime for Reach 5 is to operate as a permanently flowing stream, therefore outfall water is not surplus. The waterway is dependent on the outfall water, particularly under recent conditions (reduced flows downstream of Kerang Weir). It also helps contribute to the variability recommended in the summer low flow component.
2.2 That occurs at a time that is detrimental to the environmental values	Desired water regime for Reach 5 is to operate as a permanently flowing stream, therefore outfall water is not detrimental to environmental values. The timing of outfalls maintains water quality in permanent pools for fish. Outfalls are also at a time that would be attractive for fish.
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Irrigation water in the Torrumbarry Irrigation Area is of good quality, therefore outfall water is not detrimental to environmental values in Loddon River Reach 5 (refer to Appendix H)
3. Mitigation water may be assessed as not required where the environmental values:	
3.1 Do not directly benefit from the contribution from the irrigation system (e.g. river red gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	Reach 5 has water dependent values that directly benefit from outfall (e.g. native fish). Desired water regime for Reach 5 is to operate as a permanently flowing stream, therefore outfall water is likely to directly benefit and not be detrimental to environmental values.
4. Mitigation water may be assessed as not required where the removal of the contribution from the irrigation system does not:	
4.1 Increase the risk of reducing the environmental values (e.g. outfalls form a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk)	**Removal of outfall water would reduce flows in this reach further which would further decline the water dependent values in Reach 5.** **Increased risk of reducing environmental values including Murray Cod, Silver and Golden Perch (Refer to 'significant impact on environmental values' discussion below).**
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system)	If outfall volumes were reduced, additional EWR water may be required to meet summer low flows and summer freshes.

The above assessment demonstrates that the **outfall water provides benefit to Loddon River Reach 5 and that the provision of mitigation water is warranted if it is managed for environmental purposes** due to:

- Flows over the irrigation season will be affected over the whole flow range and particularly the low flows.
- The desired flow regime required based on revised environmental flow recommendations includes meeting summer fresh and summer base-flows. Reach 5 will be operated as a permanently flowing waterway to rehabilitate and maintain the native fish community, other aquatic habitat and water quality.
- Loddon River Reach 5 is very important for native fish by providing habitat and as an important corridor for fish movement between the Murray River and the Loddon River.
- Significant species including Murray Cod, Silver and Golden Perch will be impacted by a reduction in flows, particularly low flows. For example, reduced low flows will impact on water quality and persistence in permanent pools and therefore impact on fish species.

The above assessment demonstrates that the outfall water provides significant benefits to Loddon River Reach 5 and does support the waterway environmental values.

Source of Loddon River Reach 5 mitigation water: the revised operational rules outlined in the Kerang Weir Fishway MoU will meet all summer base-flow and summer fresh environmental flow recommendations and will mitigate the impacts of reduced channel outfall through implementation of NVIRP (Refer to Section 8.3.1).

If the above identified source of mitigation water cannot be supplied, the volume that it contributes will be made up from one of the other sources (NVIRP 2010, p50). Therefore the following steps have been calculated to provide the mitigation water assessment in an event where mitigation water is required from other sources.

Step 4: Calculate the annualised baseline mitigation water volume (BMW)

The baseline mitigation water volume is expressed as the baseline incidental water contributions divided by the number of years in the cycle of the desired water regime. Mitigation water is required in the years that Loddon River has an environmental flow recommendation (i.e. summer low flow). When the waterway is in a dry phase, no mitigation water is required.

The desired flow regime for the Loddon River Reach 5 is a permanently flowing stream. Therefore mitigation water is required every year.

Loddon River Reach 5 has multiple incidental water sources, some of which incur losses between the irrigation system and the waterway. These losses can be avoided via delivery of mitigation water from Kerang Weir, therefore the net annualised BMW are calculated below (Table 30).

Table 30: Determination of the baseline year contribution at Loddon River Reach 5

Hydrological connection or incidental water source (e.g. Outfall)	Baseline year incidental water at origin (Gross) (ML)	Baseline year incidental water at waterway (Net) (ML)	Estimated losses between origin (irrigation system) and waterway (for baseline year) (ML)	Annualised baseline mitigation water volume (ML)
ST001704	931	884	47	884
ST001744	40	40	0	40
ST001756	21	21	0	21
ST011251	0	0	0	0
ST011243	205	205	0	205
ST002302	664	664	0	664
TOTAL	**1861 ML/year**	**1814 ML/year**	**47 ML/year**	**1814 ML/year**

The annualised BMW volume for the incidental water source is calculated using the baseline year incidental water contribution at the waterway (Net), as follows:

Net BMW $_{(LR\ Reach\ 5\ Outfall\ 2004\text{-}05)}$ = Baseline year incidental water at waterway (Net) (Step 2)
Desired flow regime for Loddon River Reach 5 (Step 1)
= $931_{(ST001704)}$ + $40_{(ST001744)}$ + $21_{(ST001756)}$ + $0_{(ST011251)}$ + $205_{(ST011243)}$ + $664_{(ST002302)}$ / 1(every year)
= **1814 ML/year**

Step 5: Calculate the mitigation water commitment (MWC)

The MWC expresses the BMW (Step 4) as a percentage of the annualised baseline incidental water contribution. It is used to calculate the share of annual water savings. These are calculated each year in accordance with the Water Savings Protocol and the associated Technical Manual and will become available in any following year. The mitigation water commitment has been calculated separately for each identified hydrological connection in Table 31 below.

Table 31: Determination of the mitigation water commitment at Loddon River Reach 5

Hydrological connection or incidental water source (e.g. Outfall #)	Baseline year incidental water at origin (Gross) (ML)	Baseline year incidental water at waterway or wetland (Net) (ML)	Annualised baseline mitigation water volume (ML)	Mitigation Water Commitment (%)
ST001704	931	884	884	95%
ST001744	40	40	40	100%
ST001756	21	21	21	100%
ST011251	0	0	0	100%
ST011243	205	205	205	100%
ST002302	664	664	664	100%
TOTAL	**1861 ML/year**	**1814 ML/year**	**1814 ML/year**	**97.5%**

The overall mitigation water commitment for Loddon Reach 5 is 97.5%.

MWC (%) = Baseline Mitigation Water $_{(Loddon\ River\ Reach\ 5\ 2004\text{-}05)}$ (Step 4)
Incidental water contributions at origin (Gross) $_{(2004\text{-}05)}$ (Step 2)
= 1814 ML / 1861 ML * 100 (permanent watering regime)
= 0.975 or 97.5 %

Step 6: Calculate the LTCE mitigation water volume

The LTCE mitigation water volume is used to account for mitigation water when reporting against the net savings target. This volume is calculated by multiplying the mitigation water commitment (Step 5) by the baseline mitigation water volume (Step 4) and the LTCE conversion factor.

Please note: calculation and confirmation on the LTCE conversion factor is required from DSE. This will be decided at or near the end of the NVIRP.

8.3.1. Mitigation water provision for Reach 5

Section 9.4.2 of the Water Change Management Framework outlines the sources that mitigation water can be supplied from (e.g. existing passing flow requirements as specified in bulk entitlements) Sources of mitigating water will also be selected to ensure water can be delivered in accordance with the delivery requirements as specified in the environmental watering plans (NVIRP 2010).

As discussed in Section 6.2.3, previously over 100 ML/day was passed over Kerang Weir during the irrigation season, this arrangement was informal and was not specifically articulated in the G-MW Murray BE.

The Kerang Fishway was constructed in 2008 to provide fish passage through the Kerang Weir. The Kerang Weir Fishway and operation of the lower Loddon River Memorandum of Understanding (Kerang Fishway MoU) between North Central CMA and Goulburn-Murray Water is currently in place to outline roles and responsibilities in relation to Fishway operation.

The Kerang Weir Fishway MoU (NCCMA 2010) has been reviewed and updated to include specific operational rules to also meet summer environmental flow recommendations (summer base-flow and summer fresh). The revised Kerang Fishway MoU constitutes an agreed operating principle for G-MW and the NCCMA and would be reviewed at least on an annual basis.

Please note that DSE have agreed to the operational rules proposed in the revised Kerang Fishway MoU. Any changes to the operational rules in the MoU will require DSE signoff.

The application of the operational rules outlined in the Kerang Weir Fishway MoU will meet all summer base-flow and summer fresh environmental flow recommendations and will mitigate the impacts of reduced channel outfall through implementation of NVIRP.

Please note: if this mitigation water source (Kerang Fishway MoU) cannot be supplied, the mitigation water commitment will be required from other sources (e.g. NVIRP Gross water savings) outlined in Section 9.4.2 in the WCMF (NVIRP 2010).

9. Other environmental water sources

The calculated mitigation water only represents a small portion of the total volume of water required to provide the desired watering regime. As such, it is important to secure additional sources of water for the Loddon River. The most likely additional sources of water will be existing and future environmental entitlements. The most likely additional sources of environmental water will be existing and future environmental entitlements. Potential sources of water available for the Loddon River are discussed below.

9.1. 75GL environmental entitlement

Water savings generated by NVIRP will provide up to 75 GL to be vested in the Minister for Environment and Climate Change as an Environmental Water Entitlement. This environmental water is in addition to Government's commitments to provide water for the Living Murray process and will be used to help improve the health of stressed wetlands and waterways in Northern Victoria and the River Murray (NVIRP 2010).

In addition, the Australian Government may co-invest in Stage 2 of NVIRP which will generate up to 100 GL of water savings, some of which will be allocated to the environment. This water will be available for use across the Murray Darling Basin.

9.2. Commonwealth environmental water

Under Water for the Future the Australian Government has committed $3.1 billion to purchase water in the Murray-Darling Basin over 10 years. The program will complement a range of other measures to address sustainable water management in the Basin. The Commonwealth Environmental Water Holder, in DEWHA, will manage the Commonwealth's environmental water.

The *Water Act 2007* provides that “the Commonwealth Environmental Water Holder must perform its functions for the purpose of protecting or restoring environmental assets so as to give effect to relevant international agreements” (DEWHA 2008).

9.3. Murray Darling Basin Plan

The Murray-Darling Basin Authority is currently in the process of developing the first Murray-Darling Basin Plan as required by the *Water Act 2007*. The Basin Plan aims to establish Sustainable Diversion Limits for key environmental assets within the Murray-Darling Basin and is anticipated to commence in 2011 (MDBA 2010).

Sources of Commonwealth environmental water for the Loddon River will be influenced by the outcomes of the Basin Plan. The Loddon River has been nominated as a key environmental asset for which Sustainable Diversion Limits are likely to be established.

10. Opportunities to deliver water

The following section outlines the opportunities to deliver water including any infrastructure requirements to deliver mitigation and/or environmental water in the lower Loddon River (downstream of Loddon Weir to the Murray River).

Loddon River Reach 4

Environmental flow recommendations in Loddon River Reach 4 are delivered via the Loddon Weir, however the following recommendation would enhance the delivery of the desired flow regime:

- Use of the Number. 2 channel outfall (ST047427) as an alternative source of flows for the Loddon River, this would enable management of the significant transmission losses throughout this reach. It has been suggested that a new regulator would be required to provide flexibility in using environmental water (SKM 2010c). Modification to the chute (a concrete pipe approximately five kilometres downstream of the Twelve Mile Creek regulator) that controls flows (approximate capacity of 250 ML/day) in the Loddon River will also need to be considered.

Twelve Mile Creek

The environmental flow recommendations downstream of Loddon Weir will pass down Twelve Mile Creek (minus transmission losses). The Twelve Mile Creek regulator will need to be repaired or replaced to enable effective and flexible environmental flow delivery.

Loddon River Reach 5

Environmental flow recommendations in Loddon River Reach 5 are delivered via the Kerang Weir (including the Kerang Fishway). No additional delivery infrastructure or upgrades are required for the management of this waterway.

Please note: the current measuring and metering arrangements for streamflow is managed by G-MW.

11. Potential risks or adverse impacts

An important component of the EWPs is the identification of potential risks, limiting factors and adverse impacts associated with the delivery of the desired watering regime. Table 32 outlines the risks, limiting factors and potential impacts associated with the provision of mitigation water as a component of the desired watering regime that need to be considered by NVIRP in conjunction with the environmental water manager.

Mitigation measures have been recommended to minimise the likelihood or the risk occurring and/or its potential impact.

Table 32: Potential risks, impacts and mitigation measures associated with the provision of mitigation water to the Loddon River EWP area

Risk/limiting factors	Impacts	Mitigation measures
NVIRP		
Mitigation water was not calculated correctly	Overestimation or underestimation of the mitigation water commitment	Review Loddon River EWP recommendations in 2012
Error in quantifying the outfall losses (desktop analysis – Section 7.1.1)	May result in an underestimation of the impact and hence the need for mitigation water	Review Loddon River EWP recommendations in 2012
Mitigation water is not available at required timing	Not achieving environmental flow objectives (mitigation water is a portion of the overall watering regime)	Build management and delivery of mitigation water into environmental water management framework
Delivery of mitigation water causes adverse impacts on habitat, surrounding land, etc	Adverse impacts may result from delivery of mitigation water	Build management and delivery of mitigation water into environmental water management framework
Ineffective delivery	E.g. Kerang Fishway not used or Macorna channel cannot be used to improve water quality conditions in the Kerang weir pool	Build management and delivery of mitigation water into environmental water management framework
Opportunistic diversion licences (unregulated)[1]	Artificial lowering of water level threatening environmental flow objectives Use of environmental and mitigation water for consumptive use	Investigate options for alternative supply
Leakage and seepage assumed to be minor	Under estimation of mitigation water commitment, potential to impact on values	Review leakage and seepage estimates and EWP if significant NVRIP works (channel rationalisation and lining) are undertaken in close proximity of the waterway
Twelve Mile Creek		
Outfall water has provided environmental benefits to this waterway	Loss of environmental values	Monitoring (Appendix I) will identify any issues at Twelve Mile Creek
Reach 4		
Outfalls continue to in the irrigation season	Further colonisation of riparian species in the channel bed	Monitoring (Appendix I) will identify any outfalls that enter the waterway
Reach 5		
MoU breaking down	Loss of high environmental values. Failure to achieve identified summer freshes and low flows.	Mitigation water commitment will need to be revised

Note 1: G-MW stage 5 roster suspensions on diversions are currently in place. These are to remain in place, or appropriate restrictions implemented if not already in place, to ensure that any mitigation water delivered to wetlands and waterways is protected until such time more permanent measures are established. The roster suspensions may be temporarily lifted to allow extraction to occur where there are demonstrable alternative water supplies entering the waterway or wetland (e.g. as a result of flood).

12. Adaptive management framework

A key NVIRP principle is that an adaptive management approach is adopted to ensure an appropriate response to changing conditions (Section 9.4, NVIRP 2010).

Adaptive management is a continuous management cycle of assessment and design, implementation, monitoring, review and adjustment. Table 33 shows how the adaptive management approach will be applied in the context of this EWP.

Table 33: Adaptive management framework

Adaptive management phase	Application to this EWP (Responsible agency)	When (Sections 15 and 19, NVIRP 2010)
Assessment and design	Assessment identifies environmental values, their water dependencies, and the potential role of incidental water. Design determines the desired water regime to support environmental values and determines any mitigation water commitment. Details of both these phases are documented in this EWP. (NVIRP)	2010
Implementation	Implementation is the active management of environmental water, of which mitigation water may form a portion, consistent with this EWP. (Agencies as appropriate)	Continuous
Monitoring (and reporting)	Monitoring is gathering relevant information to facilitate review and enable any reporting obligations to be met. Two types of monitoring are required. Compliance monitoring is checking that the intended water regime is applied. Performance monitoring is used to inform the review of the effectiveness of the interim mitigation water contribution to achieving the water management goal. (NVIRP – to resource or coordinate monitoring to meet its reporting obligations, Other agencies – monitoring to inform assessment of achievement of environmental objectives).	Annual
Review	Review is evaluating actual results against objectives and identifying any improvement opportunities which may be needed. (NVIRP, until responsibilities transferred to other Agencies)	2012, 2015, 2020, 2025, etc
Adjustment	Adjustment is determining whether changes are required following review or after considering any new information or scientific knowledge and making any design changes in an updated version of the EWP. (NVIRP, until responsibilities transferred to other Agencies)	2012, 2015, 2020, 2025, etc

12.1. Monitoring and reporting

It is assumed that if mitigation water is supplied in accordance with the desired water regime proposed within the EWP then environmental values potentially impacted by NVIRP will be maintained. NVIRP will report, annually, on the contribution, or provision, of “NVIRP Mitigation Water” towards achieving the water regime (Section 18, NVIRP 2010). This will be done through liaison with other agencies in relation to monitoring and reporting whether:

- Mitigation water was available for delivery to the wetland or waterway
- A decision was made that water was required for the wetland or waterway for that year

- Mitigation water was delivered to the wetland or waterway in accordance with the desired water regime proposed within the EWP (i.e. quantity, timing, duration, frequency)
- The ecological objectives were achieved or are being achieved

The reporting of delivery of environmental water other than mitigation water is required because it is impossible to partition achievement of ecological objectives between NVIRP mitigation water and other sources of environmental water. In addition, mitigation water may only form a minor portion of the desired watering regime and is likely to be required to be delivered in association with other sources of water (i.e. environmental water allocation).

NVIRP is to include this reporting in the annual report to the Secretary of DSE.

It is expected the environmental water holder will monitor environmental water delivery (i.e. quantity, timing, duration and frequency) and implement a detailed monitoring program to enable assessment of ecological condition. NVIRP will not implement a detailed monitoring program. It is beyond the scope of this EWP to provide a detailed monitoring program to determine the effectiveness of the recommended water regime in achieving ecological objectives and the overall environmental flow regime.

NVIRP (2010, p73) states that “monitoring requirements will be designed to be consistent with the Catchment Management Authorities’ existing monitoring programs”.

There is already an ongoing environmental flow, water resource planning and water quality monitoring program for the Loddon River conducted by the North Central CMA and Goulburn-Murray Water. This monitoring program is seen as sufficient and will be used to inform the outcomes of the use of mitigation water (refer to Appendix I).

12.2. Review

Periodic reviews provide the opportunity to evaluate monitoring results in terms of compliance, ecological objectives and to learn from implementation.

It is expected this EWP will be reviewed in 2012, 2015, 2020 and every five years thereafter, or at any time, if requested by the Victorian Minister for Water or Commonwealth Minister for Environment Protection (Sections 15 and 19, NVIRP 2010).

12.3. Adjustment

Adjustments may be made to:

- operational management
- management hypotheses and, perhaps, to ecological objectives
- cope with unexpected issues.

These adjustments will be incorporated into the EWP

13. Governance arrangements

A summary of the roles and responsibilities of the various bodies relating to the delivery and review of management and mitigation measures is provided in Table 34 (NVIRP 2010). The table outlines the roles and responsibilities before and during the implementation of NVIRP in the modified GMID.

Table 34: Roles and responsibilities

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
NVIRP	• Identify and account for water savings, subject to audit by DSE accredited auditor • Lead the assessment and development processes for management and mitigation measures including developing and gaining approval to the WCMF (which guides the development of EWPs and the assessment of mitigation water). • Maintain short-list of all wetlands, waterways and groundwater dependent ecosystems for mitigation. • Identify and source mitigation water required to implement management and mitigation measures including the adaptive development of EWPs. • Retain or provide infrastructure to deliver water to wetlands and waterways. • Convene and chair the Technical Advisory Committee. • Convene the Expert Review Panel	• Apply, review and, as necessary, develop amendments and gain approval to updated versions of the WCMF. • Provides resources to enable monitoring and review of management and mitigation measures • Establish protocols for transfer of responsibility to relevant agencies. • Coordinate with other agencies to improve management and mitigation measures. • Arrange for the provision of delivery and measurement infrastructure including capacity and operational flexibility for mitigation water • Work closely with system operator.
Catchment Management Authority	• Identify and inform NVIRP of opportunities for best practice. • Inform NVIRP of its infrastructure requirements to deliver environmental water. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Agree to implementing other relevant regional management and mitigation measures required due to the implementation of NVIRP.	• Advise Environmental Water Holder and system operator on priorities for use of environmental entitlements (including mitigation water) in line with recommendations outlined in the EWPs • Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Report on environmental outcomes (e.g. wetland or waterway condition) from the delivery of the water, in the course of normal reporting on catchment condition. • Where agreed conduct the periodic review of EWPs and report results to NVIRP. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of NVIRP.
Land Manager (Public and private as relevant)	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Agree to implementing other relevant regional management and mitigation measures required due to the implementation of NVIRP.	• Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Where agreed, participate in the periodic review of relevant EWPs. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of NVIRP.

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
System Operator	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Administer management and operational arrangements.	• Implement the relevant components of Environmental Watering Plans, namely delivery of mitigation water. • Operate, maintain and replace, as needed, the infrastructure required for delivery of mitigation, or other, water, where the infrastructure is part of the G-MW irrigation delivery system. • May negotiate transfer of ownership of infrastructure to the environmental water/land manager for provision of mitigation water if it is no longer required for the public distribution system, in accordance with the principles set out in section 9. • Where the infrastructure assets are due for renewal or refurbishment, the water corporation will undertake the upgrade to the best environmental practice, including any requirements to better provide Environmental Water Reserve. • Report annually on the availability and delivery of water for mitigating environmental impacts as part of reporting upon meeting obligations under its bulk entitlement. In some instances, it will be appropriate to measure mitigation flows to ensure mitigation volumes of water are delivered. • Work closely with NVIRP
DSE	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Arrange funding to enable environmental water manager, catchment manager and land manager to deliver agreed measures. • Develop policies to address relevant issues (assuming that other agencies will participate policy development).	• Participate in the periodic review of the Water Change Management Framework and relevant EWPs. • Conduct review as part of the long-term water resource management; a requirement specified in Section 22L of the *Water Act 1989*. The process will allow: • The balance of the environmental obligations and consumptive water to be assessed and restored based on certain conditions. • The need for the obligation reviewed based on the environmental values at the time of the review.
Environmental Water Holder (to be established) **DSE pending appointment of the Environmental Water Holder**	Environmental Water Holder not yet in place. Role fulfilled by DSE in the meantime.	• Hold and manage environmental entitlements, including mitigation water that becomes a defined entitlement. • Consult with CMAs in identifying priority wetlands, waterways and groundwater systems for environmental watering. Plan and report on the use of environmental entitlements. • Participate in the periodic review of relevant EWPs. • Negotiate with Commonwealth Environmental Water Holder to arrange delivery of Commonwealth environmental water.

13.1. Framework for operational management

The obligation to annually reserve and supply mitigation water will be established in one of two ways:

- by amendment to the River Murray and Goulburn System Bulk Entitlements held by G-MW; or
- by agreement (contract) between the Minister for Environment and G-MW, under section 124(7) of the Water Act 1989.

Both arrangements are legally binding and reflect the commitments of the NVIRP to provide water to mitigate potential impacts to high value environmental assets. The arrangements require G-MW to set aside water in the Goulburn and Murray Systems to meet the mitigation water needs, calculated in accordance with the methods in the Water Change Management Framework, for future use at wetlands and waterways that have an approved EWP.

Mitigation water will be able to be carried over in line with other entitlements and will only be supplied to those wetlands where a mitigation water requirement has been identified. The specification of the volume and use of mitigation water will be the same regardless of whether it is established via bulk entitlement or contract.

Loddon River Reach 5
As outlined in Section 8.3.1, the revised operational rules in the Kerang Weir Fishway MoU will mitigate the impacts of reduced channel outfall through implementation of NVIRP. If this source of mitigation water cannot be supplied, the volume that it contributes will be made up from the obligation to annually reserve and supply mitigation water, as outlined above.

Delivery of environmental water to the Loddon River requires the coordination of information, planning and monitoring among a number of agencies. The main components are:

- Assessment of current conditions i.e. water resource outlook, water quality, season
- Annual Water Planning under the Loddon EWR BE
- Identification of 'other' potential water sources and preparation of relevant information for submission of water bid
- Coordination of the environmental water delivery and adaptive management process.

Once mitigation water is converted into a BE, the management of this entitlement will need to be incorporated into the environmental water manager's planning and reporting for the Loddon River.

14. Knowledge gaps

The Loddon River EWP has been developed using the best available information. However, a number of information and knowledge gaps exist which may impact on recommendations and/or information presented in the EWP. These are summarised below.

14.1. Works program

- Further information on the NVIRP works program especially in the vicinity of Loddon River Reach 4 needs to be confirmed to more specifically assess the potential impacts on the waterway. In particular, some outfalls have been used previously for the delivery of environmental water in reach 4.
- Leakage and seepage from NVIRP works is difficult to quantify until works have been implemented. The EWP has assumed that NVIRP works contributing to reduced leakage and seepage is minor and has not been further assessed as part of this EWP. A review of leakage and seepage estimates will be required if significant NVRIP works (channel rationalisation and lining) are undertaken in close proximity of the waterway.

14.2. Loddon and Murray Bulk Entitlement (BE)

The Lower Loddon River is influenced by both the Loddon EWR BE (Loddon Weir to upstream of the Macorna Channel) and the Murray BE (Macorna Channel to River Murray). The following should be considered when these Bulk Entitlements (BE) are reviewed:

- Revised environmental flow recommendations for the Lower Loddon River
- Proposed changes to the operation of the Lower Loddon reach 5.

14.3. Mitigation water

- The fact that the mitigation water forms only a portion of the water regime for any waterway means that its ‘value’ will often be dependent on whether other environmental water is allocated to the Loddon River. This will need to be considered in allocation decisions made by the environmental entitlement holder and/or the environmental water manager.
- The delivery and use of mitigation water and associated compliance monitoring required for the Loddon River EWP.

14.4. Roles and responsibilities

The roles and responsibilities of key agencies in the operational management of mitigation water (and other sources of environmental water) have not yet been clearly defined. A process is recommended (Section 12). However, in light of changes recommended in the Northern Region Sustainable Water Strategy (Victorian Environmental Water Holder) and the Land and Biodiversity White Paper, roles and responsibilities will need to be reviewed.

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Appendix A: NVIRP TAC and TRG Workshop Attendees

Table A1: NVIRP TAC members

Name	Organisation and Job title
Anne Graesser	Manager – Water Systems Health Goulburn-Murray Water
Emer Campbell	Manager – NRM Strategy North Central CMA
Jen Pagon	Catchment and Ecosystem Service Team Leader Department of Primary Industries
John Cooke	Manager Sunraysia Department of Sustainability and Environment
Carl Walters	Shepparton Irrigation Region Executive Officer Goulburn Broken CMA
Ross Plunkett	Executive Manager Planning NVIRP
Tamara Boyd	State Parks and Environmental Water Coordinator Parks Victoria

Table A2: TRG Workshop Attendees

Name	Organisation and Job title
Dr Andrew Sharpe	Senior Ecologist Sinclair Knight Merz
Emer Campbell	Manager- NRM Strategy North Central CMA
Erin Murrihy	Hydrologist Sinclair Knight Merz
John McGuckin	Consultant – Aquatic Ecology Streamline Research
Kate Austen	Senior Hydrologist Sinclair Knight Merz
Michelle Bills	Strategic Environmental Coordinator North Central CMA
Pat Feehan	Representing NVIRP Feehan Consulting
Prof Paul Boon	Consultant – Riparian and wetland ecology and water quality Dodo Environmental
Rohan Hogan	Science and Strategy Leader North Central CMA

APPENDIX B: Legislative framework

B1 International agreements

Australia is a signatory to the following international migratory bird agreements:

- Japan–Australia Migratory Bird Agreement (JAMBA)
- China–Australia Migratory Bird Agreement (CAMBA)
- Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention).

The Loddon River (reaches 4 and 5) are known to support species protected by each of the above international migratory bird agreements (Section 5).

B2 Federal legislation

The *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* is the key piece of legislation pertaining to biodiversity conservation within Australia. It aims to control potential impacts on matters of national environmental significance[16].

The Loddon River (reaches 4 and 5) are known to support a species listed under the *EPBC Act* (Section 5). Actions that may significantly impact any of these matters of national environmental significance are subject to assessment and approval by the Minister for the Environment, Heritage and the Arts. The NVIRP works program is also subject to assessment and approval under the *EPBC Act 1999*. A Public Environment Report documenting and assessing the potential impacts of the NVIRP on matters of national environmental significance was submitted to the Department of the Environment, Water, Heritage and the Arts (DEWHA) on 6 January 2010.

B3 State legislation

Flora and Fauna Guarantee (FFG) Act 1988

The *Flora and Fauna Guarantee (FFG) Act 1988* aims to protect a number of identified threatened species and communities within Victoria. The Loddon River (reaches 4 and 5) are known to support a number of species both protected[17] and listed under the *FFG Act* (Section 5). Disturbance or collection of any of these threatened species will require a permit from the DSE.

Environmental Effects Act 1978

Potential environmental impacts of a proposed development are subject to assessment and approval under the *Environmental Effects Act 1978*. As such, the NVIRP works program and any associated environmental impacts are subject to assessment and approval under the Act (as discussed in Section 1.1).

Planning and Environment Act 1987

The removal or disturbance to native vegetation within Victoria is controlled by the implementation of a three-step process of avoidance, minimisation and offsetting under the *Planning and Environment Act 1987*. Any proposed removal or disturbance to native vegetation associated with the NVIRP works program will require the implementation of the three-step process, assessment and approval under the Act.

Water Act 1989

The *Water Act 1989* is the key piece of legislation that governs the way water entitlements are issued and allocated in Victoria. The Act also identifies water that is to be kept for the environment under the Environmental Water Reserve. The Act provides a framework for defining and managing Victoria's water resources.

[16] There are seven MNES that are protected under the EPBC Act, these are: World Heritage properties, National Heritage places, wetlands of international importance, listed threatened species and ecological communities, migratory species protected under international agreements, Commonwealth marine areas, and nuclear actions (including uranium mines) (DEWHA 2009).

[17] Includes plant taxa belonging to families or genera protected by the Act (DSE 2009f).

Aboriginal Heritage Act 2006

All Aboriginal places, objects and human remains in Victoria are protected under the *Aboriginal Heritage Act 2006* (DPCD 2007). The Loddon River (reaches 4 and 5) are known to support sites of Aboriginal cultural significance (Section 5.4).

Other - Threatened Species Advisory Lists

Threatened species advisory lists for Victoria are maintained by the DSE and are based on technical information and advice obtained from a range of experts which are reviewed every one to two years. These advisory lists are not the same as the Threatened List established under the Victorian *FFG Act*. There are no legal requirements or consequences that flow from inclusion of a species in advisory lists. However, some of the species in these advisory lists are also listed as threatened under the *FFG Act*. The Loddon River (reaches 4 and 5) are known to support flora and fauna species that are included on advisory lists however are not protected by additional state or federal legislation.

Appendix C: Community Engagement

Rob O'Brien, Department of Primary Industries

Community Engagement purpose

Environmental Watering Plans (EWPs) are currently being developed for the lower Loddon and Campaspe rivers to determine the ecological impact of the current irrigation outfall (surplus water). An important component of this work involves identifying the environmental objective and environmental flow requirements for each of the river reaches potentially impacted by NVIRP. This requires an understanding of physical attributes, the history and the main environmental and hydrological processes associated with each of the river systems.

There have been various levels of planning and monitoring on the waterways currently being studied. To assist in collating all relevant information on each waterway it is important to capture and record information from the local community. In many cases adjoining landholders have had a long association with a waterway and have developed good understanding that is useful to include in the development of the EWP. This is particularly important if only limited monitoring records exist.

This process is also useful to increase community ownership and acceptance of the EWP, particularly if ongoing work involves onground works.

Similar to the Wetland EWPs completed in association with the Loddon River EWP, a targeted community/agency engagement process was developed where a list of people with a good technical understanding of the river reach being assessed was developed by the technical working group.

This list included key adjoining landholders who have had a long association with the waterway and proven interest in maintaining its environmental value. A minimum of two landholders were invited to provide input for each river reach.

Other community and agency people who can provide useful technical and historic information include G-MW water bailiffs, duck hunters (Field & Game), bird observers and field naturalists.

The information is captured in brief dot point form and only technical information and observations have been noted that will add value to the development of the EWP.

A list of participants has been recorded; however, comments for each river reach have been combined so individual comments are not referenced back to individuals.

It is important that the people approached for this information have a brief, straight summary of the purpose of the EWPs and type of information that will be useful to include in the planning process. Refer to summary below:

Method

A targeted community/agency engagement process was developed for the first round of EWPs developed in early 2009. A list of people with a good technical understanding of each waterway was developed by the technical working group (DPI, DSE and North Central CMA representatives).

This list included key adjoining landholders that have had a long association with the waterway and proven interest in maintaining its environmental value. A minimum of 2 landholders were invited to provide input for each river reach.

The method of obtaining information was informal and occurred at the site (e.g. oral histories, interviews). The information is captured in brief dot point form and only technical information and observations are to be noted that will add value to the development of the EWP.

A list of participants is recorded however all the comments have been combined for each of the river reaches so individual comments are not referenced back to individuals.

List of community and agency participants

Loddon River Reach 4 (including Twelve Mile Creek)

- Margaret Munroe
- Rod Stringer
- Ken Buchanan
- Barry Barnes
- Paul & Cathy Haw

Loddon River Reach 5

- Elaine Jones
- Colin Myres
- John Baulch
- Peter Koetveld

Note: the results below document the comments received from the community members approached as part of the community engagement process. However, if new information comes to light this can be amended and redistributed accordingly.

Information provided to participants

We are currently completing a study for NVIRP. It involves completing plans for the lower Loddon and Campaspe rivers:

1. Campaspe River (downstream of Campaspe Weir to Murray River)
2. Loddon River (downstream of Loddon Weir to Murray River)
3. Twelve Mile Creek (anabranch of the Loddon River)

As part of this, it would be valuable to gather information that is broadly described below with a focus on the water regime and associated waterway values. It is recognised that these waterways have been altered significantly since European settlement and the expansion of irrigated agriculture.

Providing information on these changes and how they influenced and altered the waterways is important. It is particularly important to collate information or observations over more recent times, such as the last 30–50 years.

- What was the original (pre-European settlement) condition of this section of the Loddon River, including any detail of the water regime and environmental values?
- What connection did the Loddon River have to the floodplain areas creek lines and wetlands and there behaviour in both flood and dry times?
- What broad changes to river management have occurred as part of European Settlement and agricultural development?
- What function did the river have in the development of the irrigation supply system?
- What changes occurred to the environmental values as part of increased river regulation?
- More recently what changes have occurred to the water regime and health of the Loddon River since the mid 1900's?
- Describe notable plants and animals that utilised the river over time?
- What influence do the artificial structures have on river flow or health?
- Given the history and current condition what water regime would be needed to achieve the best environmental results for the river and adjacent floodplain?
- What role does outfall from the G-MW channel have?
- o Given the history and current condition, what type of water regime would be needed to achieve the best environmental results for the waterway?

Comments and feedback from participants for the Loddon River Loddon River Reach 4 (including Twelve Mile Creek)

Loddon River natural/pre European settlement condition

- The Loddon River flowed mostly in winter and spring but rarely in summer.
- Vegetation particularly native grasses grew down to the waters edge.
- Early Explorers in the 1830's recorded the river was difficult to travel along as it was "ever changing" and highly variable.

Changed Loddon River regulation and management over time

- The Loddon River and associated floodplain was grazed by domestic stock managed by the areas stations (i.e. Station Country).
- The Northern floodplain was recognised as good grazing country.
- Local Aboriginal people would conduct controlled burning of the landscape in autumn or early winter.
- Stocking rates of 11,000 to 12,000 sheep over 84,000 were recorded. Larger flocks were separated into smaller flocks of 1000 sheep were controlled by a shepherd and a Hut Keeper over a specified area.
- Fencing occurred in the 1860s when land ownership was clarified and this allowed stocking rates to increase, sometimes double and this lead to overgrazing.
- Leaghur Dam was constructed around 1850's and designed to direct water to the west via natural creeks to fill lakes such as Lake Leaghur and Lake Meran.
- Early settlers located their houses away from the Loddon River near wetlands that had more reliable water supply but protected from flooding.
- Early settlers increased the flows out of the Loddon River into Black Fellows Creek, which denied the Loddon River significant quantities of water, however at the time considered the right thing to do.
- The Durham Ox area was originally called Duck Swamp.
- Wells to access groundwater in the Yando area were generally brackish, slightly saline.
- There were several deep holes along the Loddon River that held water after the river stopped flowing.
- Several Weirs were constructed within the Loddon River from the 1850s to 1880s.
- Early pioneering settlers had difficulties securing a reliable stock and domestic water supply.
- Pioneers settling around Boort (i.e. Boort Station) Godfrey would graze the dryland Mallee area in the winter and graze along the Loddon River in the summer months.
- After a long extended dry period the Loddon River and associated wetlands and creeks would completely dry. In 1851 the nearest access to water was at Lake Boga.
- From the 1920s to the 1960s the Loddon River was extensively used as an irrigation supply carrier particularly upstream of the Chute and Gannons Weir.
- Structures such as the Chute have caused the river upstream to become excessively silted up and capacity is lost.
- Cumbungi was previously sprayed and controlled by departmental staff where it choked up the Loddon River, particularly upstream of the Chute. This was necessary as this plant choked the river.
- The Loddon River, which runs around Canary Island, has high environmental value.
- The bars were removed at Gannon's Weir in the 1960s and replaced by a fixed crest weir.
- After the 1960s the G-MW channel system was expanded and the Loddon received less irrigation water and fluctuated more.
- Many of the deeper holes in the Loddon River have been infilled by silt.
- The River Channel has silted up significantly over time, however this is site specific as some may still be near natural condition, or some perhaps scoured out lower.
- When irrigation water was plentiful there where significant channel outfalls and excessive irrigation runoff, which kept smaller floodplain creek lines wet and many, had high environmental values.
- From 1965 the Stringer family leased and grazed Leaghur Forest, which drained well after a flood event but also received additional outfall water.

Current condition of the Loddon River

- There is minimal salinity along the Loddon River between Fernihurst and Appin South.
- High watertables and high groundwater conditions are also influenced by irrigation practices. There is minimal irrigation, close to the Loddon River in the top section of the Loddon River until the Appin South area.
- The acid sulphate conditions downstream of Fernihurst Weir are a small isolated section of the river that is influenced by groundwater.
- The watertables beneath “Majors Line” may be influenced from leakage from the Loddon Weir Pool and the Waranga Western Channel 7 km further upstream.
- The “Chute” has done a lot of damage to the Loddon River by slowing up the water flow, increasing siltation and reducing the capacity of River to carry and spread the water across the floodplain.
- The 12 Mile Creek is variable in condition with some sections very heavily grazed, particularly the southern sections while other areas containing a good assemblage of native plants.
- During a flood a lot more water travels around the Twelve Mile Creek than the Loddon River.
- The Loddon River around the east side of Canary Island also contains very good environmental values, including very old Red Gums along the banks.
- Trees can block the flow of the river and change the river course.
- Red Gum trees have regenerated very thickly between Yando Road and the Macorna Main Channel. This may be due to the significant outfalls that occurred along this section of the river and the reduced flow of the Loddon.
- A significant G-MW channel outfall event along Caldwell Road (greater 1000 ML) did not travel very far down the Loddon River due to the river bed being so dry and plants blocking the flows.
- Lots of summer weeds grew due to the low summer flows around 2000 and 2001.
- G-MW channel outfalls that enter the river travel both upstream and downstream due the very flat landscape.
- The regenerating Red Gums within the river channel will restrict and alter the flow within the Loddon River that they will cause the death of the larger, more valuable trees along the river banks and jeopardise other environmental values away from the river onto the floodplain.
- The mature Red Gum trees along the river in the Appin area are mostly dead.

Suggested flow regime and management to improve the Loddon River.

- The 12 Mile Regulator is required to manipulate water each side of Canary Island because the floodplain is that highly modified and that the best result is achieved by actively using the water.
- In moderate to high flood events the 12 Mile Creek naturally carries a lot more water than the Loddon River.
- The Loddon River would benefit if flows are delivered in the cooler winter months and allow the river to dry completely in summer.
- No summer flows and most of the flows in winter.
- Little environmental benefit is gained from delivering low flows down the river (i.e. 20 ML to 40 ML) and it is preferable to not deliver any water until a reasonable flow (i.e. greater 100 ML/day) is available.
- There are huge soakage losses associated with delivering environmental water flows down a dry Loddon River bed.
- Fencing off the Loddon River is very important as it improves the native vegetation cover, protects the soils and will allow other values to return when the system floods again.
- If a low flow event reaches Canary Island and the 12 Mile Regulator then there is little benefit in splitting this flow and water should be directed either down the 12 Mile or the Loddon River.
- To improve the health of the large old trees along the Loddon River there may be little benefit of providing a low/shallow flow down the river as their roots may not get access to the moisture. To benefit tree health along the banks its best to have a full river and the volume to achieve this will alter along different sections.

- There are advantages of injecting water from the G-MW Irrigation Supply Channel into the Loddon River to supplement environmental water flows as it's difficult to inject all of the required water at the top of the river reach, in the rivers current modified condition.
- Pulsing larger flows at the commencement of any desired low environmental flows would assist in pushing the water through that section of the river, particularly forcing a path through the accumulated debris and vegetation.
- Short term light pulse grazing is preferable along the river.

Loddon River Reach 5

Loddon River natural/pre European settlement condition

- The Bar Creek is a geological drain, scoured out form flows originating from the Murray River during an unstable/saline phase.
- The rivers and wetlands throughout this district were naturally intermittent.
- The Lower Loddon River and floodplain was very productive however variable variable/unreliable.

Changed Loddon River regulation and management over time

- The water in the Loddon River was manipulated by early settlers in the late 1800s.
- In the early days water forced out onto the floodplain was very productive as the fertile clay soils responded well to being irrigated. This was a boom time as the problems associated with high water tables and salinisation was not apparent until many years later.
- The height of the water whin the early Torrumbarry Irrigation Supply System (1923) was about 600 mm higher that the current Torrumbarry Irrigation Supply System. The lowering of the Torrumbarry Supply System occurred in the 1960s and this reduced water table heights and there was a considerable improvement in the health of the area.
- When the Loddon Weir Pool is lifted water spills over the fixed crest Kerang Weir and water flows down the Lower Loddon River.

Current condition of the Loddon River

- Irrigations developments have lead to a deterioration of the Loddon River.
- The waterbirds that use the Loddon River vary considerably where 73 species were recorded along the Loddon River and associated swamps just downstream of Kerang during a wet phase.
- Red Gum trees have regenerated higher up on the floodplain during large flood events. These trees survived well during the series of wet years however the past decade has seen them decline or die due to reduced flooding. Black Box trees are replacing the gum in some areas. Lippia/Fog-fruit (*Phyla canescens*) is a significant environmental problem as it dominates and cover the ground outcompeting most native species.
- Lippia was intentionally planted on the Levees around Kerang to stabilise the banks was spread rapidly and dominates native areas, particularly around the Loddon River.
- The water quality within the Kerang Weir Pool has become very poor. It varies considerably however currently very turbid, contains black organic particles and periodically suffers blue green algae blooms.
- The poor water quality within the Loddon River reduces agricultural production, particularly higher value horticultural production (& herb growing).
- Carp have done considerable environmental damage to local rivers and wetlands.
- Cumbungi growth has choked the river up and there is a need continue to undertake control measures.
- The decaying organic matter, including Cumbungi stems is now decaying and small black particles are suspended in the water column.
- Over recent years the Kerang Weir Pool has stagnated with almost no through flow and this lack of flow further deteriorates the water quality.
- There is a slight reduction is carp numbers in recent years and a small improvement in aquatic plant growth however the water is still very turbid other measures need to be taken to address the source of the problem.

- The levee banks are far too close to the river in sections downstream of Kerang with some being placed right on the rivers edge. These close levels need to be breached or better off completely removed to allow floodwater to spread.
- The Loddon River continues to deteriorate over time.

Suggested flow regime and management to improve the Loddon River

- There is a need to artificially or unnaturally supply water to maintain the new environmental values that have been created.
- Reach 4 could be managed more as an ephemeral or seasonal system and water delivered within the cooler months.
- Reach 5 from Kerang to the Little Murray River is better managed as a permanent system and flows delivered more continuously.

Appendix D: Flows method

The environmental flow recommendations provided in sections 5.1.3, 5.2.3 and 5.3.3 outline the desired watering regime for the Loddon River and are used as part of the calculations for mitigation water (Section 8).

The FLOWS method which has been specifically developed for determining environmental water requirements in Victoria was used to determine environmental flow requirements for the Loddon River, including:

- Reach 4 (between the Loddon Weir and Kerang Weir)
- Twelve Mile creek
- Reach 5 (between the Kerang Weir and the Murray River)

The FLOWS method is based on the concept that key components of the natural flow regime influence various biological, geomorphological and physico-chemical processes in waterways. It involves the collection of information through desktop studies, field assessments and stakeholder consultation (Figure D1) (DNRE 2002).

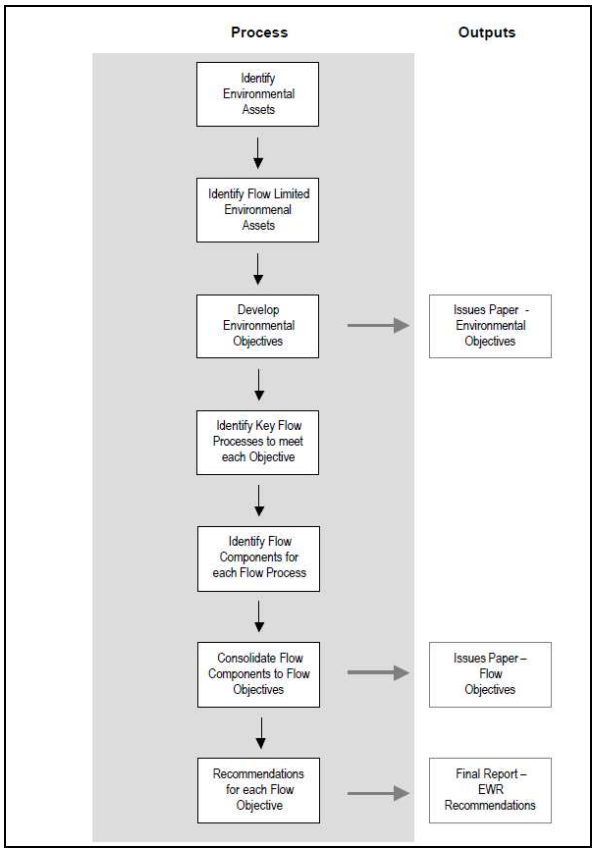


Figure D1: Outline of the process for the determination of environmental and flow objectives

The intent of an environmental flows study (FLOWS method) is to state objectives that would, if met, mean that the flow could sustain an ecologically healthy river. Therefore the objectives are developed not only to protect current conditions or environmental assets of concern, such as threatened species, but also to sustain natural communities and processes that are essential for river health (DNRE 2002). The steps below summarise the process undertaken in the FLOWS method:

Step 1: Identify current environmental assets

A list of current environmental assets (species and communities) is collated. While this list is not restricted to threatened biota it is critical that the flow recommendations do describe conditions required for their protection.

- *Particular species and communities*
    - Species: threatened aquatic invertebrates, all fish, all frogs, all aquatic reptiles, all aquatic mammals, colonial water birds, threatened water birds, threatened aquatic and riparian plants
    - Communities: Riparian Ecological Vegetation Classes, Wetlands of significance (Ramsar, DIWA, Bioregion), AusRivAS score for the aquatic invertebrate community
- *Flagship/locally significant species/communities*
- *Habitats*
    - Channel morphology (pools, benches, riffles etc.)
    - Instream habitat: large woody debris, aquatic vegetation
    - Wetlands
- *Ecological processes*
    - Linkages/connectivity
    - Geomorphic processes
    - Nutrient cycling

Step 2: Identify assets expected to be associated with a "healthy" waterway

The environmental assets that need to be reinstated or improved in order to achieve the 'ecological healthy state' are identified.

Step 3: Develop environmental objectives

From steps 1 and 2, a group of assets are selected which are flow dependent and for which there is good understanding of their flow requirements. Environmental objectives are developed for each environmental asset.

Step 4: Identify key flow related events and flow components to meet each environmental objective

For each environmental asset, the flow-related events or processes that are critical in order to meet the environmental objectives are identified. There may be a number of these for each asset. The flow related events may be to meet a biological need, such as a trigger for spawning, or to provide physical habitat, such as inundation of snags or maintenance of suitable water quality in pools. An example is provide in Table D1 below.

Table D1: Example of flow processes and components for Murray Cod

Ecological asset	Objective	Flow related events	Flow component
Murray Cod	Self sustaining populations of Murray Cod	1. Movement 2. Recruitment 3. Habitat availability in summer 4. Water quality in summer	1.High flow(winter) 2.Freshes (winter/spring) 3.Low flow (summer) 4.Freshes (summer)

Step 5: Develop flow objectives

Each flow component is described in terms of timing, frequency or duration required to meet the environmental objectives. The flow objectives must meet the requirements of the environmental objectives.

Step 6: Develop recommendations to meet each flow objective

The environmental water recommendations are developed to provide the described flow objectives (Hydraulic modelling).

Adapted from DNRE 2002

Appendix E: Flora and Fauna Species List

Compiled: September 2009
Sources:
Data Source: *Biodiversity Interactive Map*. Department of Sustainability and Environment http://mapshare2.dse.vic.gov.au/MapShare2EXT/imf.jsp?site=bim (Accessed November 2009)

DSE (2009b) Data Source: 'Threatened Fauna 100' © The State of Victoria, Department of Sustainability and Environment. Accessed: November 2009.

DSE (2009e) Data Source: 'Threatened Flora 100' © The State of Victoria, Department of Sustainability and Environment. The contribution of the Royal Botanical Gardens Melbourne to the data is acknowledged. Accessed: November 2009.

Loddon River Reach 4 Flora and fauna species

Flora Key

- Conservation status: v = vulnerable in Victoria, e = endangered; r = rare in Victoria; k = poorly known in Victoria; inadequate distribution information.
- * = introduced; # = native but now extends beyond natural distribution

Common Name	Scientific Name	Origin	EPBC	VROTS	FFG
African Box-thorn	*Lycium ferocissimum*	*			
Alkali Sida	*Malvella leprosa*	*			
Annual Beard-grass	*Polypogon monspeliensis*	*			
Annual Bluebell	*Wahlenbergia gracilenta s.l.*				
Annual Cudweed	*Euchiton sphaericus*				
Australian Hollyhock	*Malva australiana s.l.*				
Barley Grass	*Hordeum spp.*	*			
Barley-grass	*Hordeum murinum s.l.*	*			
Bathurst Burr	*Xanthium spinosum*	*			
Bearded Oat	*Avena barbata*	*			
Berry Saltbush	*Atriplex semibaccata*				
Berry Seablite	*Suaeda baccifera*	*			
Birdsfoot Clover	*Trifolium ornithopodioides*	*			
Black Box	*Eucalyptus largiflorens*				
Black Cotton-bush	*Maireana decalvans*				
Black Nightshade	*Solanum nigrum sensu Willis (1972)*	*			
Black Roly-poly	*Sclerolaena muricata*				
Blackseed Glasswort	*Halosarcia pergranulata*				
Bluish Raspwort	*Haloragis glauca f. glauca*			k	
Bottle Bluebush	*Maireana excavata*				
Bristly Wallaby-grass	*Austrodanthonia setacea*				
Broad-leaf Cumbungi	*Typha orientalis*				
Brome	*Bromus spp.*				
Brown-back Wallaby-grass	*Austrodanthonia duttoniana*				
Burr Medic	*Medicago polymorpha*	*			
Canary Grass	*Phalaris spp.*	*			
Cape Weed	*Arctotheca calendula*	*			
Cat's Ear	*Hypochoeris spp.*	*			
Centaury	*Centaurium spp.*	*			
Centella	*Centella spp.*				
Chicory	*Cichorium intybus*	*			
Clover	*Trifolium spp.*	*			
Club Sedge	*Isolepis spp.*				
Clustered Dock	*Rumex conglomeratus*	*			

Common Name	Scientific Name	Origin	EPBC	VROTS	FFG
Coast Barb-grass	*Parapholis incurva*	*			
Common Blown-grass	*Lachnagrostis filiformis*				
Common Cudweed	*Euchiton involucratus s.l.*				
Common Nardoo	*Marsilea drummondii*				
Common Peppercress	*Lepidium africanum*	*			
Common Reed	*Phragmites australis*				
Common Sneezeweed	*Centipeda cunninghamii*				
Common Sow-thistle	*Sonchus oleraceus*	*			
Common Spike-sedge	*Eleocharis acuta*				
Common Swamp Wallaby-grass	*Amphibromus nervosus*				
Common Tussock-grass	*Poa labillardierei*				
Common Wallaby-grass	*Austrodanthonia caespitosa*				
Common Woodruff	*Asperula conferta*				
Copper-awned Wallaby-grass	*Austrodanthonia fulva*				
Couch	*Cynodon dactylon var. dactylon*	*			
Crassula	*Crassula spp.*				
Creeping Knotweed	*Persicaria prostrata*				
Creeping Mint	*Mentha satureoides*				
Curled Dock	*Rumex crispus*	*			
Daisy	*Brachyscome spp.*				
Dark Roly-poly	*Sclerolaena muricata var. semiglabra*			k	
Desert Spear-grass	*Austrostipa eremophila*				
Divided Sedge	*Carex divisa*	*			
Dock	*Rumex spp.*				
Drain Flat-sedge	*Cyperus eragrostis*	*			
Dwarf Bluebush	*Maireana humillima*				
Fen Sedge	*Carex gaudichaudiana*				
Fennel	*Foeniculum vulgare*	*			
Ferny Cotula	*Cotula bipinnata*	*			
Ferny Small-flower Buttercup	*Ranunculus pumilio*				
Fescue	*Vulpia spp.*	*			
Finger Rush	*Juncus subsecundus*				
Flase Brome	*Brachypodium distachyon*	*			
Flat Sedge	*Cyperus spp.*				
Flat Spurge	*Chamaesyce drummondii*	#			
Forde Poa	*Poa fordeana*				
Giant Mustard	*Rapistrum rugosum*	*			
Gold Rush	*Juncus flavidus*				
Grassland Wood-sorrel	*Oxalis perennans*				
Great Brome	*Bromus diandrus*	*			
Grey Roly-poly	*Sclerolaena muricata var. villosa*				
Grey Tussock-grass	*Poa sieberiana*				
Hair Grass	*Aira spp.*	*			
Hairy Hawkbit	*Leontodon taraxacoides subsp. taraxacoides*	*			
Hare's-foot Clover	*Trifolium arvense var. arvense*	*			
Heron's Bill	*Erodium spp.*				
Hill Wallaby-grass	*Austrodanthonia eriantha*				

Common Name	Scientific Name	Origin	EPBC	VROTS	FFG
Hollow Rush	*Juncus amabilis*				
Jagged Bitter-cress	*Rorippa laciniata*				
Kangaroo Grass	*Themeda triandra*				
Kidney-weed	*Dichondra repens*				
Knob Sedge	*Carex inversa*				
Knotted Barley-grass	*Hordeum secalinum*	*			
Knotty Spear-grass	*Austrostipa nodosa*				
Leafy Wallaby-grass	*Austrodanthonia bipartita s.l.*				
Lesser Canary-grass	*Phalaris minor*	*			
Lesser Joyweed	*Alternanthera denticulata s.l.*				
Lesser Quaking-grass	*Briza minor*	*			
Lucerne	*Medicago sativa subsp. sativa*	*			
Mallow	*Malva spp.*	*			
Mediterranean Brome	*Bromus lanceolatus*	*			
Narrow-leaf Clover	*Trifolium angustifolium var. angustifolium*	*			
Narrow-leaf Cumbungi	*Typha domingensis*				
Narrow-leaf Dock	*Rumex tenax*				
Narrow-leaf Nardoo	*Marsilea costulifera*				
Narrow-leaf Sida	*Sida trichopoda*				
Nitre Goosefoot	*Chenopodium nitrariaceum*				
Nodding Saltbush	*Einadia nutans subsp. nutans*				
Onion Grass	*Romulea rosea*	*			
Ox-tongue	*Helminthotheca echioides*	*			
Pale Beauty-heads	*Calocephalus sonderi*				
Pale Goodenia	*Goodenia glauca*				
Pale Spike-sedge	*Eleocharis pallens*			k	
Paper Sunray	*Rhodanthe corymbiflora*				
Paradoxical Canary-grass	*Phalaris paradoxa*	*			
Paspalum	*Paspalum dilatatum*	*			
Perennial Rye-grass	*Lolium perenne var. perenne*	*			
Pink Bindweed	*Convolvulus erubescens spp. agg.*				
Plains Sedge	*Carex bichenoviana*				
Plump Spear-grass	*Austrostipa aristiglumis*				
Poison Pratia	*Lobelia concolor*				
Poong'ort	*Carex tereticaulis*				
Prickly Lettuce	*Lactuca serriola*	*			
Prostrate Knotweed	*Polygonum aviculare s.l.*	*			
Quena	*Solanum esuriale*				
Rat's-tail Fescue	*Vulpia myuros*	*			
Rat-tail Couch	*Sporobolus mitchellii*				
Red Brome	*Bromus rubens*	*			
Red-leg Grass	*Bothriochloa macra*				
Rigid Panic	*Whalleya proluta*				
River Red-gum	*Eucalyptus camaldulensis*				
Riverine Flax-lily	*Dianella porracea*			v	
Rough Burr-daisy	*Calotis scabiosifolia*				
Rough Raspwort	*Haloragis aspera*				
Rough Sow-thistle	*Sonchus asper s.l.*	*			

Common Name	Scientific Name	Origin	EPBC	VROTS	FFG
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*				
Rush	*Juncus spp*				
Rye Grass	*Lolium spp.*	*			
Sagittaria	*Sagittaria platyphylla*	*			
Saltbush	*Atriplex spp.*				
Scorzonera	*Scorzonera laciniata*	*			
Sea Barley-grass	*Hordeum marinum*	****			
Sedge	*Carex spp.*				
Sharp Buttercup	*Ranunculus muricatus*	*			
Sheep's Burr	*Acaena echinata*				
Slender Centaury	*Centaurium tenuiflorum*	*			
Slender Dock	*Rumex brownii*				
Slender Mint	*Mentha diemenica*				
Slender Monkey-flower	*Mimulus gracilis*				
Small Loosestrife	*Lythrum hyssopifolia*				
Small Spike-sedge	*Eleocharis pusilla*				
Small-flower Onion-grass	*Romulea minutiflora*	*			
Small-leaf Goosefoot	*Chenopodium desertorum subsp. microphyllum*				
Sneezeweed	*Centipeda spp.*				
Soft Brome	*Bromus hordeaceus*	****			
Soursob	*Oxalis pes-capre*	****			
Southern Cane-grass	*Eragrostis infecunda*				
Spear Grass	*Austrostipa spp.*				
Spear Thistle	*Cirsium vulgare*	****			
Spreading Crassula	*Crassula decumbens var. decumbens*				
Spreading Goodenia	*Goodenia heteromera*				
Spreading Sneezeweed	*Centipeda minima s.l.*				
Spurred Spear-grass	*Austrostipa gibbosa*				
Squirrel-tail Fescue	*Vulpia bromoides*	****			
Star Fruit	*Damasonium minus*				
Stinkwort	*Dittrichia graveolens*	*			
Stiped Wallaby-grass	*Austrodanthonia racemosa*				
Strawberry Clover	*Trifolium fragiferum var. fragiferum*	*			
Subterranean Clover	*Trifolium subterraneum*	*			
Suckling Clover	*Trifolium dubium*	*			
Swamp Buttercup	*Ranunculus undosus*			v	
Swamp Starwort	*Stellaria angustifolia*				
Tah-vine	*Boerhavia dominii*	#			
Tall Fireweed	*Senecio runcinifolius*				
Tall Flat-sedge	*Cyperus exaltatus*				
Tangled Lignum	*Muehlenbeckia florulenta*				
Toowoomba Canary-grass	*Phalaris aquatica*	****			
Tough Scurf-pea	*Cullen tenax*			e	L
Tufted Bluebell	*Wahlenbergia communis s.l.*				
Tufted Burr-daisy	*Calotis scapigera*				
Tussock Rush	*Juncus aridicola*				
Twin-leaf Bedstraw	*Asperula gemella*			r	

Common Name	Scientific Name	Origin	EPBC	VROTS	FFG
Variable Sida	*Sida corrugata*				
Variable Willow-herb	*Epilobium billardierianum*				
Varied Raspwort	*Haloragis heterophylla*				
Victorian Club-sedge	*Isolepis victoriensis*				
Wall Fescue	*Vulpia muralis*	*			
Warrego Summer-grass	*Paspalidium jubiflorum*	#			
Water Ribbons	*Triglochin procera s.l.*				
Water-milfoil	*Myriophyllum spp.*				
Wild Oat	*Avena fatua*	*			
Willow Wattle	*Acacia salicina*				
Wimmera Rye-grass	*Lolium rigidum*	*			
Windmill Grass	*Chloris truncata*				
Wingless Bluebush	*Maireana enchylaenoides*				
Wood Sorrel	*Oxalis spp.*				
Woodland Swamp-daisy	*Brachyscome basaltica var. gracilis*				
Woodruff	*Asperula spp.*				

Fauna

Key

- Conservation status: CR = Critically endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; DD = Data deficient; L = listed under the *Flora and Fauna Guarantee Act 1988;* J/C = listed under the Japan–Australia Migratory Bird Agreement (JAMBA) or China–Australia Migratory Bird Agreement (CAMBA).
- * = introduced

Common Name	Scientific Name	Origin	EPBC	VROTS	FFG
Fish					
Australian Smelt	*Retropinna semoni*				
Bony Herring	*Nematalosa erebi*				
Carp Gudgeon	*Hypseleotris compressa*				
Common Carp	*Cyprinus carpio*	*			
Flat-Headed Gudgeon	*Philypnodon grandiceps*				
Gambusia	*Gambusia holbrooki*	*			
Golden perch	*Macquaria ambigua*			VU	
Goldfish	*Carassius auratus*	*			
Murray Cod	*Maccullochella peelii peelii*		VU	EN	L
Redfin Perch	*Perca fluviatilis*	*			
River Blackfish	*Gadopsis marmoratus*				
Silver perch	*Bidyanus bidyanus*			CE	L
Tench	*Tinca tinca*	*			
Red Fox	*Vulpes vulpes*	*			
Water Rat	*Hydromys chrysogaster*				

Common Name	Scientific Name	Origin	International Agreements	EPBC	VROTS	FFG
Birds						
Australian Magpie	*Gymnorhina tibicen*					
Australian Pelican	*Pelecanus conspicillatus*					
Australian White Ibis	*Threskiornis molucca*					
Banded Stilt	*Cladorhynchus leucocephalus*					
Black Swan	*Cygnus atratus*					
Black-faced Cuckoo-	*Coracina novaehollandiae*					

Common Name	Scientific Name	Origin	International Agreements	EPBC	VROTS	FFG
shrike						
Black-fronted Dotterel	*Elseyornis melanops*					
Black-tailed Native-hen	*Gallinula ventralis*					
Black-winged Stilt	*Himantopus himantopus*					
Brolga	*Grus rubicunda*				VU	L
Brown Treecreeper	*Climacteris picumnus*				NT	
Chestnut Teal	*Anas castanea*					
Cockatiel	*Nymphicus hollandicus*					
Common Greenshank	*Tringa nebularia*		J/C/R/B			
Common Starling	*Sturnus vulgaris*	*				
Crested Pigeon	*Ocyphaps lophotes*					
Dusky Moorhen	*Gallinula tenebrosa*					
Eastern Rosella	*Platycercus eximius*					
Galah	*Cacatua roseicapilla*					
Great Crested Grebe	*Podiceps cristatus*					
Great Egret	*Ardea alba*		J/C		VU	L
Grey Shrike-thrush	*Colluricincla harmonica*					
Grey Teal	*Anas gracilis*					
Intermediate Egret	*Ardea intermedia*				CR	L
Latham's Snipe	*Gallinago hardwickii*		J/C		NT	
Little Black Cormorant	*Phalacrocorax sulcirostris*					
Little Pied Cormorant	*Phalacrocorax melanoleucos*					
Long-billed Corella	*Cacatua tenuirostris*					
Magpie Goose	*Anseranas semipalmata*				VU	L
Magpie-lark	*Grallina cyanoleuca*					
Marsh Sandpiper	*Tringa stagnatilis*		J/C/R/B			
Masked Lapwing	*Vanellus miles*					
Noisy Miner	*Manorina melanocephala*					
Pacific Black Duck	*Anas superciliosa*					
Purple Swamphen	*Porphyrio porphyrio*					
Red Wattlebird	*Anthochaera carunculata*					
Red-kneed Dotterel	*Erythrogonys cinctus*					
Red-rumped Parrot	*Psephotus haematonotus*					
Royal Spoonbill	*Platalea regia*				VU	
Rufous Songlark	*Cincloramphus mathewsi*					
Sharp-tailed Sandpiper	*Calidris acuminata*		J/C			
Silver Gull	*Larus novaehollandiae*					
Straw-necked Ibis	*Threskiornis spinicollis*					
Superb Fairy-wren	*Malurus cyaneus*					
Swamp Harrier	*Circus approximans*					
Whiskered Tern	*Chlidonias hybridus*				NT	
White-faced Heron	*Egretta novaehollandiae*					
White-plumed Honeyeater	*Lichenostomus penicillatus*					
Willie Wagtail	*Rhipidura leucophrys*					
Yellow-billed Spoonbill	*Platalea flavipes*					

Twelve Mile Creek Flora species

Flora Key

- Conservation status: v = vulnerable in Victoria; r = rare in Victoria; k = poorly known in Victoria; inadequate distribution information.
- * = introduced; # = native but now extends beyond natural distribution

Common Name	Scientific Name	Origin	EPBC	FFG	VROTS
Lesser Joyweed	*Alternanthera denticulata s.l.*				
Common Swamp Wallaby-grass	*Amphibromus nervosus*				
Twin-leaf Bedstraw	*Asperula gemella*			r	
Brown-back Wallaby-grass	*Austrodanthonia duttoniana*				
Wild Oat	*Avena fatua*	*			
Woodland Swamp-daisy	*Brachyscome basaltica var. gracilis*				
Mediterranean Brome	*Bromus lanceolatus*	*			
Tufted Burr-daisy	*Calotis scapigera*				
Poong'ort	*Carex tereticaulis*				
Water Buttons	*Cotula coronopifolia*	*			
Swamp Billy-buttons	*Craspedia paludicola*				
Drain Flat-sedge	*Cyperus eragrostis*	*			
Kidney-weed	*Dichondra repens*				
Yellow Twin-heads	*Eclipta platyglossa*	#			
Pale Spike-sedge	*Eleocharis pallens*			k	
Small Spike-sedge	*Eleocharis pusilla*				
Variable Willow-herb	*Epilobium billardierianum*				
River Red-gum	*Eucalyptus camaldulensis*				
Annual Cudweed	*Euchiton sphaericus*				
Grassland Crane's-bill	*Geranium retrorsum s.l.*				
Bluish Raspwort	*Haloragis glauca f. glauca*			k	
Ox-tongue	*Helminthotheca echioides*	*			
Gold Rush	*Juncus flavidus*				
Common Blown-grass	*Lachnagrostis filiformis*				
Prickly Lettuce	*Lactuca serriola*	*			
Hairy Hawkbit	*Leontodon taraxacoides subsp. taraxacoides*	*			
Poison Pratia	*Lobelia concolor*				
Perennial Rye-grass	*Lolium perenne*	*			
Small Loosestrife	*Lythrum hyssopifolia*				
Narrow-leaf Nardoo	*Marsilea costulifera*				
Common Nardoo	*Marsilea drummondii*				
Slender Mint	*Mentha diemenica*				
Creeping mint	*Mentha satureoides*				
Robust Water-milfoil	*Myriophyllum papillosum*				
Grassland Wood-sorrel	*Oxalis perennans*				
Warrego Summer-grass	*Paspalidium jubiflorum*	#			
Paradoxical Canary-grass	*Phalaris paradoxa*	*			
Forde Poa	*Poa fordeana*				
Ferny Small-flower Buttercup	*Ranunculus pumilio*				
Swamp Buttercup	*Ranunculus undosus*			v	
Jagged Bitter-cress	*Rorippa laciniata*				
Slender Dock	*Rumex brownii*				
Clustered Dock	*Rumex conglomeratus*	*			
Curled Dock	*Rumex crispus*	*			
Narrow-leaf Dock	*Rumex tenax*				

Common Name	Scientific Name	Origin	EPBC	FFG	VROTS
Willow	*Salix spp.*	*			
Swamp Starwort	*Stellaria angustifolia*				
Birdsfoot Clover	*Trifolium ornithopodioides*	*			
Water Ribbons	*Triglochin procera s.l.*				

Loddon River Reach 5 Flora and fauna species

Flora Key

- Conservation status: v = vulnerable in Victoria; r = rare in Victoria; k = poorly known in Victoria; inadequate distribution information.
- * = introduced; # = native but now extends beyond natural distribution

Common Name	Scientific Name	Origin	EPBC	FFG	VROTS
African Box-thorn	*Lycium ferocissimum*	*			
Annual Beard-grass	*Polypogon monspeliensis*	*			
Argentine Cress	*Lepidium bonariense*	*			
Aster-weed	*Aster subulatus*	*			
Austral Mudwort	*Limosella australis*				
Barley Grass	*Hordeum spp.*	*			
Berry Saltbush	*Atriplex semibaccata*				
Billabong Rush	*Juncus usitatus*				
Black Box	*Eucalyptus largiflorens*				
Black Roly-poly	*Sclerolaena muricata var. muricata*				k
Blue Sow-thistle	*Sonchus asper subsp. glaucescens*	*			
Bluish Raspwort	*Haloragis glauca f. glauca*				k
Bristly Wallaby-grass	*Austrodanthonia setacea*				
Buttercup	*Ranunculus spp.*				
Cane Grass	*Eragrostis australasica*				v
Cat's Ear	*Hypochoeris radicata*	*			
Caustic Weed	*Chamaesyce spp.*	*			
Clove-strip	*Ludwigia peploides subsp. montevidensis*				
Coast Barb-grass	*Parapholis incurva*	*			
Common Blown-grass	*Lachnagrostis filiformis var.1*				
Common Boobialla	*Myoporum insulare*	#			
Common Peppercress	*Lepidium africanum*	*			
Common Reed	*Phragmites australis*				
Common Spike-sedge	*Eleocharis acuta*				
Cotton Fireweed	*Senecio quadridentatus*				
Couch	*Cynodon dactylon var. dactylon*	*			
Curled Dock	*Rumex crispus*	*			
Delicate Hair-grass	*Aira elegantissima*	*			
Desmazeria	*Tribolium acutiflorum s.l.*	*			
Dock	*Rumex spp.*				
Drain Flat-sedge	*Cyperus eragrostis*	*			
Fat Hen	*Chenopodium album*	*			
Ferny Cotula	*Cotula bipinnata*	*			
Fog-fruit	*Phyla spp*	*			
Forde Poa	*Poa fordeana*				
Grass	*Poaceae spp.*				
Grey Roly-poly	*Sclerolaena muricata var. villosa*				
Hedge Saltbush	*Rhagodia spinescens*				
Hollow Rush	*Juncus amabilis*				
Inland Pigface	*Carpobrotus modestus*				

Common Name	Scientific Name	Origin	EPBC	FFG	VROTS
Jagged Bitter-cress	*Rorippa laciniata*				
Kidney-weed	*Dichondra repens*				
Knob Sedge	*Carex inversa*				
Knotted Barley-grass	*Hordeum secalinum*	*			
Lesser Canary-grass	*Phalaris minor*	*			
Lesser Joyweed	*Alternanthera denticulata s.l.*				
Mallow	*Malva spp.*	*			
Mousetail	*Myosurus minimus var. australis*				
Nitre Goosefoot	*Chenopodium nitrariaceum*				
Nodding Saltbush	*Einadia nutans subsp. nutans*				
Paspalum	*Paspalum dilatatum*	*			
Perennial Rye-grass	*Lolium perenne var. perenne*	*			
Plains Sedge	*Carex bichenoviana*				
Poong'ort	*Carex tereticaulis*				
Prickly Saltwort	*Salsola tragus subsp. tragus*				
Prostrate Knotweed	*Polygonum aviculare s.l.*	*			
Rat-tail Couch	*Sporobolus mitchellii*				
Red Brome	*Bromus rubens*	*			
River Club-sedge	*Schoenoplectus tabernaemontani*				
River Red-gum	*Eucalyptus camaldulensis*				
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*				
Rush	*Juncus spp*				
Sagittaria	*Sagittaria platyphylla*	*			
Sea Barley-grass	*Hordeum marinum*	*			
Small Spike-sedge	*Eleocharis pusilla*				
Soft Brome	*Bromus hordeaceus*	*			
Southern Cane-grass	*Eragrostis infecunda*				
Spear Thistle	*Cirsium vulgare*	*			
Spiked Centaury	*Centaurium spicatum*				
Sprawling Saltbush	*Atriplex suberecta*				
Spreading Emu-bush	*Eremophila divaricata subsp. divaricata*				r
Squirrel-tail Fescue	*Vulpia bromoides*	*			
Stinkwort	*Dittrichia graveolens*	*			
Swamp Crassula	*Crassula helmsii*				
Tall Fireweed	*Senecio runcinifolius*				
Tall Flat-sedge	*Cyperus exaltatus*				
Tangled Lignum	*Muehlenbeckia florulenta*				
Tufted Burr-daisy	*Calotis scapigera*				
Twinleaf Bedstraw	*Asperula gemella*				r
Varied Raspwort	*Haloragis heterophylla*				
Warrego Summer-grass	*Paspalidium jubiflorum*	#			
Water Starwort	*Callitriche spp.*				
Wetland Blown-grass	*Lachnagrostis filiformis var.2*				k
Willow Wattle	*Acacia salicina*				
Wingless Bluebush	*Maireana enchylaenoides*				
Woodland Swamp-daisy	*Brachyscome basaltica var. gracilis*				

Fauna

Key

- Conservation status: CR = Critically endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; DD = Data deficient; L = listed under the *Flora and Fauna Guarantee Act 1988;* J/C = listed under the Japan–Australia Migratory Bird Agreement (JAMBA) or China–Australia Migratory Bird Agreement (CAMBA).
- * = introduced

Common Name	Scientific Name	Origin	EPBC	VROTS	FFG
Fish					
Australian Smelt	*Retropinna semoni*				
Carp Gudgeon	*Hypseleotris spp.*				
Common Carp	*Cyprinus carpio*	*			
Flat-headed Gudgeon	*Philypnodon grandiceps*				
Gambusia	*Gambusia holbrooki*	*			
Golden Perch	*Macquaria ambigua*			VU	I
Goldfish	*Carassius auratus*	*			
Murray Cod	*Maccullochella peelii peelii*		VU	EN	L
Murray-Darling Rainbowfish	*Melanotaenia fluviatilis*			DD	L
Redfin	*Perca fluviatilis*	*			
Silver Perch	*Bidyanus bidyanus*			CR	L
Unspecked Hardyhead	*Craterocephalus stermuscuscarum fulvus*			DD	L
Mammals					
Common Brushtail Possum	*Trichosurus vulpecula*				
House Mouse	*Mus musculus*	*			
Water Rat	*Hydromys chrysogaster*				
Reptiles					
Turtle	*Chelodina sp.*				

Common Name	Scientific Name	Origin	International Agreements	EPBC	FFG	VROTS
Birds						
Australasian Grebe	*Tachybaptus novaehollandiae*					
Australian Magpie	*Gymnorhina tibicen*					
Australian Pelican	*Pelecanus conspicillatus*					
Australian Shelduck	*Tadorna tadornoides*					
Australian Wood Duck	*Chenonetta jubata*					
Black Kite	*Milvus migrans*					
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*					
Black-shouldered Kite	*Elanus axillaris*					
Black-tailed Native-hen	*Gallinula ventralis*					
Brown Falcon	*Falco berigora*					
Bush Stone-curlew	*Burhinus grallarius*				L	EN
Common Bronzewing	*Phaps chalcoptera*					
Common Starling	*Sturnus vulgaris*	*				
Crested Pigeon	*Ocyphaps lophotes*					
Dusky Moorhen	*Gallinula tenebrosa*					
Dusky Woodswallow	*Artamus cyanopterus*					
Eastern Rosella	*Platycercus eximius*					
Flame Robin	*Petroica phoenicea*					
Galah	*Cacatua roseicapilla*					

Common Name	Scientific Name	Origin	International Agreements	EPBC	FFG	VROTS
Gilbert's Whistler	*Pachycephala inornata*					
Great Egret	*Ardea alba*		J/C		L	VU
Grey Shrike-thrush	*Colluricincla harmonica*					
Grey-crowned Babbler	*Pomatostomus temporalis*				L	EN
House Sparrow	*Passer domesticus*	*				
Laughing Kookaburra	*Dacelo novaeguineae*					
Little Black Cormorant	*Phalacrocorax sulcirostris*					
Little Pied Cormorant	*Phalacrocorax melanoleucos*					
Little Raven	*Corvus mellori*					
Magpie-lark	*Grallina cyanoleuca*					
Nankeen Kestrel	*Falco cenchroides*					
Nankeen Night Heron	*Nycticorax caledonicus*					NT
Noisy Miner	*Manorina melanocephala*					
Pacific Black Duck	*Anas superciliosa*					
Pied Butcherbird	*Cracticus nigrogularis*					
Red-capped Robin	*Petroica goodenovii*					
Red-rumped Parrot	*Psephotus haematonotus*					
Royal Spoonbill	*Platalea regia*					VU
Sacred Kingfisher	*Todiramphus sanctus*					
Southern Boobook	*Ninox novaeseelandiae*					
Straw-necked Ibis	*Threskiornis spinicollis*					
Striated Pardalote	*Pardalotus striatus*					
Superb Fairy-wren	*Malurus cyaneus*					
Variegated Fairy-wren	*Malurus lamberti*					
White-faced Heron	*Egretta novaehollandiae*					
White-fronted Chat	*Epthianura albifrons*					
White-plumed Honeyeater	*Lichenostomus penicillatus*					
White-winged Fairy-wren	*Malurus leucopterus*					
Willie Wagtail	*Rhipidura leucophrys*					
Zebra Finch	*Taeniopygia guttata*					

Appendix F: Outfall Assessments

F1 Waterway outfall volumes

Irrigation Area	Asset Code	Channel	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
PBIA	ST047427	No 2	0	0	10	3	0	0	13	46	21	0	0	0
PBIA	ST023628	No 2 Spur	84	26	24	30	0	2	4	46	50	4	0	0
PBIA	ST023234	No 2	1275	818	725	629	528	284	443	493	562	115	166	12
PBIA	ST025135	9/2	187	185	154	146	182	22	94	60	126	4	0	0
PBIA	ST023738	3/2/8/2	34	64	15	5	1	0	0	5	15	2	0	0
PBIA	ST023230	1/9/2	61	60	17	32	13	9	17	17	51	2	0	0
PBIA	ST009820	1/1/12	34	11	0	12	46	10	21	84	74	0	0	0
PBIA	*ST009806*	2/1/1/12	4	0	0	0	0	0	0	1	0	0	0	0
Totals			**1679**	**1164**	**945**	**857**	**770**	**327**	**592**	**752**	**899**	**127**	**166**	**12**
TIA	ST001704	No 1		905	1289	621	755	944	859	931	669	574.4	25	73
TIA	ST002302	No 4 -		904	1124	0	1117	746	160	664	511	412	8	36
TIA	ST001744	6		0	30	8	0	0	0	40	0	0	0	0
TIA	ST001756	6		72	47	18	37	28	98	21	35	0	0	0
TIA	ST011251	No 7/1/7		0	0	0	0	0	0	0	0	0	0	0
TIA	ST011243	No 1/7		952	320	264	392	267	243	205	145	100.5	0	0
Totals				**2833**	**2810**	**911**	**2301**	**1985**	**1360**	**1861**	**1360**	**1086.9**	**33**	**109**

Recorded outfall volumes – cumulative volumes

The cumulative outfall volumes for Loddon River Reach 4, Twelve Mile Creek and Loddon River Reach 5 are illustrated below.

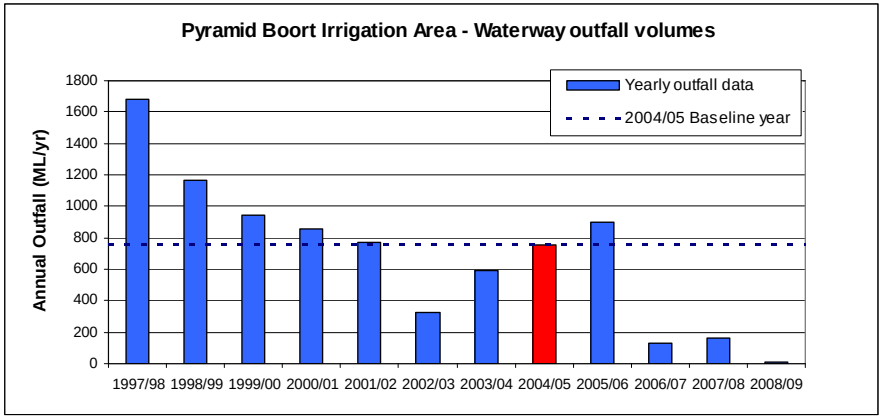


Figure F1: Outfall volumes for the Loddon River Reach 4 (Pyramid-Boort Irrigation Area)[18]

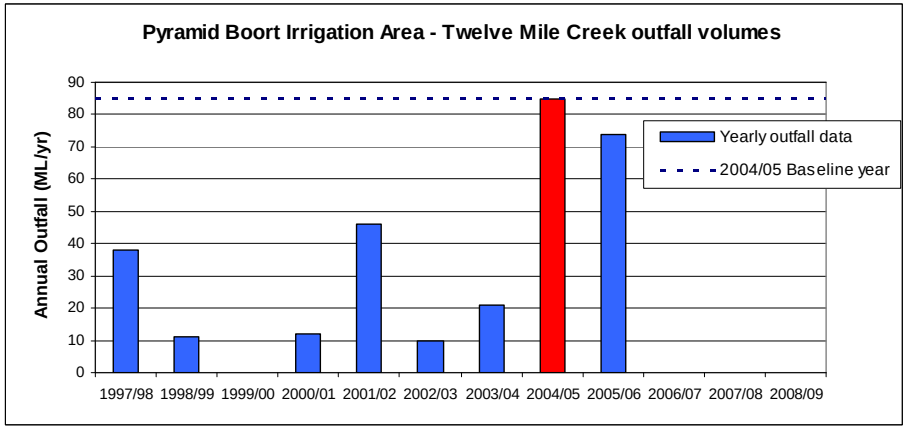
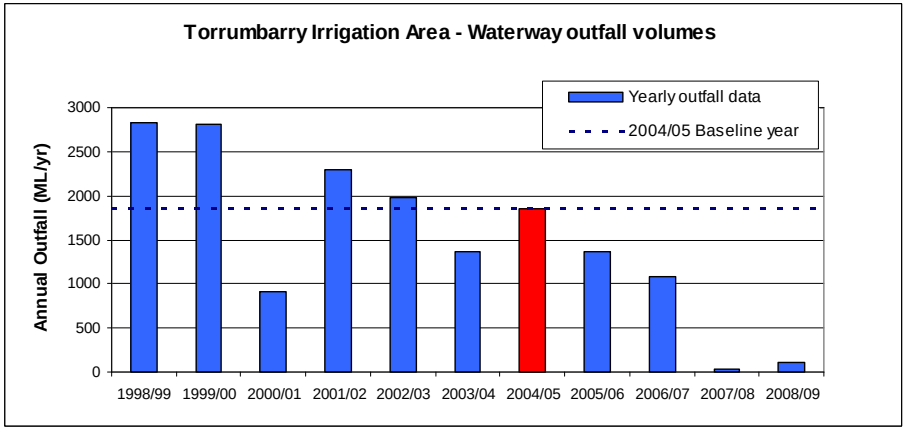


Figure F2: Outfall volumes for the Twelve Mile Creek (Pyramid-Boort Irrigation Area)



FigureF3: Outfall volumes for the Loddon River Reach 5 (Torrumbarry Irrigation Area)

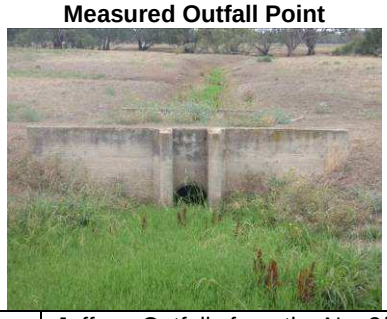
[18] Please note: The Twelve Mile Creek flows back into the Loddon River, therefore the outfall volumes from the Twelve Mile Creek have been included in the Loddon Reach 4 assessment above.

F2 Waterway outfall site descriptions

Please Note: the overall refuge rating at each outfall site (waterway receiving point) is based on the ability for the site to sustain populations of water-dependent flora and fauna at the time of field assessment. The following table broadly describes the qualitative criteria used for this rating:

Rating	Drought refuge characteristics
Excellent	Diverse habitat types in excellent condition - Large, deep pool and/or riffle habitat of varying depths - Presence of submerged (10-30% of substrate covered) and emergent aquatic vegetation (15-30% of channel margins) - Large woody debris, undercut banks, heterogeneous substrate - Excellent water quality (compliance with SEPP (WoV)) - Good connection (i.e. no barriers) with other habitat close-by - Established riparian zone that provides shading (>20% of channel) - No stock access
Good	Diverse habitat types in good condition - Deep pool and/or riffle habitat of varying depths - Presence of submerged (5-10% of substrate covered) and emergent aquatic vegetation (5-15% of channel margins) - Large woody debris, undercut banks, heterogeneous substrate - Good water quality (rare exceedance of SEPP (WoV)) - Good connection (i.e. no barriers) with other habitat close-by - Established riparian zone that provides shading (5-20% of channel) - No stock access
Moderate	Suitable habitat in moderate condition - Deep pool or riffle habitat - Limited submerged (<5% of substrate covered) and emergent aquatic vegetation (<5% of channel margins) - Large woody debris or undercut banks - Moderate water quality (occasionally exceeds SEPP (WoV)) - Limited connection (i.e. only during high flows) with other habitat nearby - Sparse riparian zone with limited shading (0-5% of channel) - Limited stock access
Poor	Limited habitat diversity in poor condition - Shallow, homogenous channel - Minimal aquatic vegetation, large woody debris and/or undercut banks - Poor water quality (frequently exceeds SEPP (WoV)) - Unconnected to other habitats nearby - Sparse riparian zone - Stock access
Very Poor	No habitat diversity and in poor condition - Shallow, homogenous channel (e.g. heavily silted) - No habitat features, e.g. aquatic vegetation, large woody debris - Very poor water quality (i.e. high turbidity, high EC, low DO) - Isolated from other potential habitats - No riparian zone - Stock access

(Source: SKM 2009)

PYRAMID BOORT IRRIGATION AREA			WGS1984 Zone 54
Receiving Waterway : Twelve Mile Creek		**Irrigation Outfall : 2/1/1/12 (ST009806)**	
Easting	0756428	**Northing**	6007804
Measured Outfall Point 		**Waterway receiving point** 	
Description	Jeffery: Outfalls from the No. 2/1/1/12 channel to the top of 12 Mile Creek (~ 12 km from the Loddon)		
Waterway Characteristics at outfall site		**Refuge Rating at waterway receiving point (Key Water dependent values):**	
Depth	<30cm	Undercut banks	No
Width	25m	Large woody debris	Minor
Velocity	No flow	Aquatic vegetation	Water Couch, Cumbungi and Phragmites
Riparian Zone	Continuous	Rating	Poor
Stock access	Yes	2004/05 Outfall Volume	1 ML
Receiving Waterway : Twelve Mile Creek		**Irrigation Outfall : 1/1/12 (ST009820)**	
Easting	0757139	**Northing**	6011036
Measured Outfall Point 		**Waterway receiving point** 	
Description	Chalmers: Outfalls from the No. 1/1/12 channel approximately half way down 12 Mile Creek (~10 km from the Loddon)		
Waterway Characteristics at outfall site		**Refuge Rating at waterway receiving point (Key Water dependent values):**	
Depth	Dry	Undercut banks	No
Width	20m	Large woody debris	Minor
Velocity	No flow	Aquatic vegetation	Annual weeds and mixture of native sedges and rushes
Riparian Zone	Continuous RRG and perennial grasses	Rating	Poor
Stock access	Controlled	2004/05 Outfall Volume	84 ML
Receiving Waterway : Loddon River		**Irrigation Outfall : No 2 (ST047427)**	
Easting	0754709	**Northing**	6011122
Measured Outfall Point 		**Waterway receiving point** 	
Description	Gannons: Outfalls from the No. 2 channel direct to the Loddon River via the Wandella Creek breakaway (~0.5 km).		

Waterway Characteristics at outfall site		Refuge Rating at waterway receiving point (Key Water dependent values):	
Depth	Dry	Undercut banks	No
Width	30m	Large woody debris	Moderate
Velocity	No flow	Aquatic vegetation	Cumbungi and couch grass
Riparian Zone	RRG and grasses	Rating	Poor
Stock access	No	2004/05 Outfall Volume	

Receiving Waterway : Loddon River		Irrigation Outfall : No 2 (ST023234)	
Easting	0758245	**Northing**	6017681

Measured Outfall Point

Waterway receiving point

Description	River Pool: Outfalls from the No. 9/2 channel direct to the Loddon River

Waterway Characteristics at outfall site		Refuge Rating at waterway receiving point (Key Water dependent values):	
Depth	Dry	Undercut banks	No
Width	20m	Large woody debris	Moderate
Velocity	No flow	Aquatic vegetation	Cumbungi and rushes
Riparian Zone	RRG (poor health, some dead)	Rating	Poor
Stock access	No evidence	2004/05 Outfall Volume	493 ML

Receiving Waterway : Loddon River		Irrigation Outfall : No 2 Spur (ST023628)	
Easting	0758094	**Northing**	6023231

Measured Outfall Point

Waterway receiving point

Description	Delamare: Outfalls from the bottom of the No. 2 Spur Channel to a short drain (~ 1 km) then a creek (Sheepwash ~ 0.5 km) • Farmer uses creek at water re-use system • Brolgas breed at this site each year (Cliff Wood, Landholder, pers comm., 2010)

Waterway Characteristics at outfall site		Refuge Rating at waterway receiving point (Key Water dependent values):	
Depth	~50cm	Undercut banks	No
Width	15m	Large woody debris	No
Velocity	<0.05m/s	Aquatic vegetation	Cumbungi
Riparian Zone	Bare and salt affected	Rating	Moderate
Stock access	Yes	2004/05 Outfall Volume	46 ML

Receiving Waterway : Loddon River		Irrigation Outfall : No 1/9/2 (ST023230)	
Easting	0758754	**Northing**	6023378

Measured Outfall Point

Waterway receiving point

Description	Delamare: Outfalls from the No. 1/9/2 channel direct to the Loddon River via a short drain (~0.5 km)

Waterway Characteristics at outfall site		**Refuge Rating at waterway receiving point (Key Water dependent values):**	
Depth	Dry	Undercut banks	No
Width	10m	Large woody debris	Minor
Velocity	No flow	Aquatic vegetation	Cumbungi
Riparian Zone	Lignum and dead RRG (salt affected)	Rating	Poor
Stock access	Yes	2004/05 Outfall Volume	17 ML

Receiving Waterway : Loddon River		Irrigation Outfall : No 9/2 (ST025135)	
Easting	0762768	**Northing**	6028961

Measured Outfall Point

Waterway receiving point

Description	Dowdy's: Outfalls from the No. 9/2 channel to a drain (~1 km) the to the Loddon River near the Macorna channel outfall

Waterway Characteristics at outfall site		**Refuge Rating at waterway receiving point (Key Water dependent values):**	
Depth	Dry	Undercut banks	No
Width	40m	Large woody debris	Moderate
Velocity	No flow	Aquatic vegetation	Cumbungi and Phragmites
Riparian Zone	RRG, lignum and Black Box	Rating	Poor
Stock access	Controlled grazing	2004/05 Outfall Volume	60 ML

Receiving Waterway : Loddon River		Irrigation Outfall : No 3/2/8/2 (ST023738)	
Easting	0760120	**Northing**	6029769

Measured Outfall Point

Waterway receiving point

Description	Duncan: Outfalls from the No. 3/2/8/2 channel to a short drain/creek system (~1 km) before flowing into the Loddon River

Waterway Characteristics at outfall site		Refuge Rating at waterway receiving point (Key Water dependent values):	
Depth	Dry	Undercut banks	No
Width	30m	Large woody debris	Moderate
Velocity	No flow	Aquatic vegetation	Sedges, rushes and native grasses. RRG in channel
Riparian Zone	RRG (poor health) and lignum	Rating	Poor
Stock access	Fenced off	2004/05 Outfall Volume	10 ML

TORRUMBARRY IRRIGATION AREA

Receiving Waterway : Loddon River		Irrigation Outfall : No 1 (ST001704)	
Easting	0764288	**Northing**	6052371

Measured Outfall Point

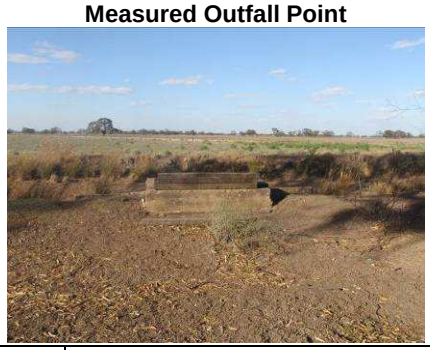
Waterway receiving point

Description	Outfalls to a drain (~1.5 km) (large river with a few siphons) then to the river

Waterway Characteristics at outfall site		Refuge Rating at waterway receiving point (Key Water dependent values):	
Depth	~50cm	Undercut banks	No
Width	20m	Large woody debris	Minor
Velocity	No flow	Aquatic vegetation	Cumbungi
Riparian Zone	RRG, Black Box, Lignum	Rating	Moderate
Stock access	Yes	2004/05 Outfall Volume	930.5 ML

Receiving Waterway : Loddon River		Irrigation Outfall : No 6 (ST001744)	
Easting	0763632	**Northing**	6055154

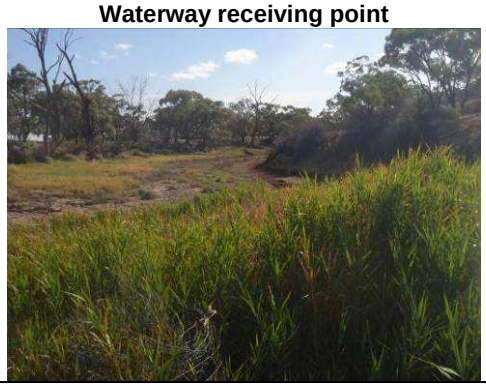
Measured Outfall Point



Waterway receiving point

Description	Outfalls directly to the Loddon River from the No. 6 channel (Off Kerang-Murrabit Rd – McKnight)

Waterway Characteristics at outfall site		Refuge Rating at waterway receiving point (Key Water dependent values):	
Depth	<50cm	Undercut banks	No
Width	20m	Large woody debris	Minor
Velocity	No flow	Aquatic vegetation	Cumbungi and Cane Grass
Riparian Zone	RRG, Black Box, Lignum	Rating	Moderate
Stock access	Heavily grazed	2004/05 Outfall Volume	40 ML

Receiving Waterway : Loddon River		Irrigation Outfall : No 6 (ST001756)	
Easting	0762304	**Northing**	6059593
Measured Outfall Point		**Waterway receiving point**	
			
Description	Heffer Rd: Outfalls directly to the Loddon River from the bottom of the No. 6 channel		
Waterway Characteristics at outfall site		**Refuge Rating at waterway receiving point (Key Water dependent values):**	
Depth	Drying	Undercut banks	No
Width	20m	Large woody debris	Minor
Velocity	No flow	Aquatic vegetation	Phragmites
Riparian Zone	Chenopods, Lignum, RRG and Black Box	Rating	Poor
Stock access	No evidence (controlled)	2004/05 Outfall Volume	21 ML

Receiving Waterway : Loddon River		Irrigation Outfall : No 7/1/7 (ST011251)	
Easting	0758894	**Northing**	6066005
Measured Outfall Point		**Waterway receiving point**	
			
Description	Outfalls directly to the Loddon River from the No. 7/1/7.		
Waterway Characteristics at outfall site		**Refuge Rating at waterway receiving point (Key Water dependent values):**	
Depth	<1m	Undercut banks	No
Width	25m	Large woody debris	Minor
Velocity	<0.05m/s	Aquatic vegetation	Cumbungi, Sedges and rushes
Riparian Zone	Lignum, RRG and Wattle	Rating	Good
Stock access	Controlled, lightly grazed	2004/05 Outfall Volume	0 ML

Receiving Waterway : Loddon River		Irrigation Outfall : No 1/7 (ST011243)	
Easting	0757062	**Northing**	6068445
Measured Outfall Point		**Waterway receiving point**	
			
Description	Upstream of Benjaroop, outfalls directly to the Loddon River from the No. 1/7 channel		

Waterway Characteristics at outfall site		Refuge Rating at waterway receiving point (Key Water dependent values):	
Depth	~1m	Undercut banks	No
Width	30m	Large woody debris	Minor
Velocity	<0.05m/s	Aquatic vegetation	Emerged aquatics
Riparian Zone	Lignum, RRG and Wattle	Rating	Good
Stock access	Fenced off	2004/05 Outfall Volume	205 ML
Receiving Waterway : Loddon River		**Irrigation Outfall : No 4 (ST002302)**	
Easting	0756168	**Northing**	6069582

Measured Outfall Point

Waterway receiving point

Description	Benjaroop: Outfalls directly to the Loddon River from the bottom of the No. 4 channel

Waterway Characteristics at outfall site		Refuge Rating at waterway receiving point (Key Water dependent values):	
Depth	~1m	Undercut banks	No
Width	30m	Large woody debris	Minor
Velocity	<0.05m/s	Aquatic vegetation	Azolla, Phragmites and Water Couch
Riparian Zone	Lignum, Wattle and RRG	Rating	Good
Stock access	No	2004/05 Outfall Volume	664 ML

Appendix G: Technical Reference Group Review

File Note

Date 17 March 2010

Project No VW04984

Subject **Technical Reference Group review of draft Loddon River Long-term Environmental Watering Plan**

1. Introduction

The North Central Catchment Management Authority (NCCMA) engaged SKM to assemble a Technical Reference Group (TRG) to review the draft Loddon River Environmental Watering Plan (EWP), which the NCCMA prepared for the Northern Victorian Irrigation Renewal Project (NVIRP). The EWP is only concerned with the effect that an 85% reduction in irrigation channel outfalls will have on the environmental values of the Loddon River downstream of Loddon Weir, including Twelve Mile Creek. The EWP aims to identify the current environmental condition, establish environmental objectives and recommend broad water regimes that will protect/enhance the environmental values in the lower Loddon River.

The TRG comprised scientists and engineers with experience in water quality, aquatic ecology, riparian and wetland ecology and hydrology in the Loddon River and Campaspe River catchments. The purpose of the review is to determine whether the EWP has sufficient scientific rigour and to provide advice on how information gaps, omissions or errors can be addressed. TRG members individually reviewed the draft EWP and discussed relevant issues at a workshop, which was held at SKM on 15th March. The outcome of the TRG reviews and workshop are discussed below.

Table 1-1: Composition of the Technical Reference Group.

TRG member and affiliation	Relevant area of experience
Kate Austin (SKM)	Hydrology
Paul Boon (Dodo Environmental)	Riparian and wetland ecology and water quality
John McGuckin (Streamline Research)	Fish ecology and water quality
Andrew Sharpe (SKM)	Environmental flows, aquatic ecology and water quality

2. General structure and comments

The Draft Loddon River Long-term Environmental Watering Plan has a clear structure that is logical and easy to follow. For the most part it is also well written. The individual assessment for each outfall is particularly good because it ensures that localised benefits or impacts associated with channel outfalls are not missed. Specific comments are provided below under theme headings.

2.1. Separating the influence of channel outfalls from other flow related factors.

Assessing the likely impact of outfall reductions on a river system is problematic because many factors influence the amount of flow at any given time. It is also very difficult to determine whether the supply of mitigation water is effective. The best that the EWP can do is to assess the relative contribution that outfalls make to flow at any given time and ask whether an 85% reduction in the estimated contribution is likely to make it more likely or less likely that the environmental watering objectives for the waterway are being met. If a reduction in channel outfalls is considered to represent an environmental risk and mitigation water is required then the most appropriate form of monitoring should focus on whether the mitigation water is delivered where and when recommended. It is unlikely that any biological monitoring program will be able to demonstrate the effectiveness of delivering mitigation water. It would be useful for the EWP to discuss this point at the start of Section 7.

2.2. Estimating the contribution of channel outfalls

It is important to understand how channel outfalls vary over time in order to fully assess the impact that reduced outfalls are likely to have on environmental values. The EWP reports monthly contributions from channel outfalls and also highlights annual variations since

1997/98 (see Figures 6 and 7). While useful, these statistics do not indicate what is happening over much shorter timescales. Channel outfalls only represent a small proportion of the total flow in the lower Loddon River, but if most of the outfall volumes are delivered over a short period of time then they may significantly contribute to a particular flow event (e.g. a summer fresh) or at least increase flow variability.

The EWP would benefit from an analysis to determine the range of daily outfall contributions (i.e. the expected maximum daily outfall volume), some estimate of errors associated with these estimates and a discussion about when specific outfall events are likely to occur. The TRG understand that daily data are not available, however an analysis of weekly data including statistics on weekly maximum and minimum contributions will be more useful than the monthly data that have been used. The analysis should also consider how the range of weekly outfalls vary between wet years and dry years and investigate the extent to which they are likely to contribute to river flows in different years. One approach may be to super-impose the environmental flow recommendations on a modelled flow series to determine the extent to which, and how often, channel outfalls contribute to meeting these recommendations.

The TRG considered that outfall events in the lower Loddon River would be most likely driven by demand rather than weather patterns (e.g. rainfall rejection). However, that assumption needs to be tested and the outcome discussed. If outfalls are demand driven, then it should be relatively simple to use weekly demand to estimate the timing and magnitude of outfalls at different locations.

2.3. Description and definition of environmental values

The EWP focuses on biota of high conservation significance, especially species that are listed under the Victorian FFG Act and the Commonwealth EPBC Act. The focus on biota with recognised conservation significance is too narrow and doesn't recognise the value of other populations and communities or the role that they play in broader ecosystem processes and function. Moreover there is little discussion of the water dependency of many of the listed species.

Using the environmental flow recommendations as a benchmark for determining whether a reduction in channel outfalls is likely to threaten environmental values in the Loddon River overcomes the problem of focussing on threatened species because the environmental flow recommendations were initially developed to meet a wide variety of environmental objectives. The TRG feel that the link between the environmental flow recommendations and the broader range of environmental values needs to be made clearer in the EWP. Moreover, the EWP needs a better definition of high environmental values, which may be done by referring to the Regional River Health Strategy, and a clear statement about addressing the requirements of all known environmental values.

2.4. Explanation of baseline year and other reference periods in the assessment

The assessment presented in the EWP frequently refers to the 2004/05 Baseline year, but there is no discussion about why this year was selected and how it is being used in the assessment. The TRG had some concerns about the relevance of the single Baseline year given infrastructure upgrades since then have already reduced the magnitude of some channel outfalls and the recent drought may have irreversibly altered the composition and condition of environmental values in the waterway. The EWP should include a section that clearly describes how and why the baseline year is used in the analysis.

Figures 6 and 7 present total annual outfall volumes to the Loddon River from the Pyramid Boort and Torrumbarry Irrigation Areas since 1997/98 and 1998/99 respectively. These figures include specific references to the 2004/05 Baseline year, a long-term average (1998 onwards) and a short-term average (2007/08 and 2008/09). There is no discussion or justification for selecting these periods and no clear analysis that includes these reference periods. Moreover a short-term average based on only two data points is probably meaningless. If these reference periods are to be retained, then the EWP needs to include a discussion about the relevance of these averages and how they should be interpreted. A better approach would be to use modelled data from the period of the Goulburn Simulation Model (i.e. from 1896 onwards) and model different scenarios of interest. Short-term averages should be based on some variation of the last 10 years.

2.5. General issues to be addressed

Errors in the environmental flow recommendation tables.

Tables 7, 10 and 15 summarise the environmental flow recommendations for the lower Loddon River. Tables 7 and 10 describe frequencies and durations for summer and winter low flows. Both of these flow components are intended to be delivered continuously rather than as discrete events and so the frequency and duration references should be deleted.

The second line in Table 7 suggests that the described environmental flow recommendations relate to sub-reaches 4a, 4c and 4d, which is not true. Large losses between Loddon Weir and Twelve Mile Creek mean that flow recommendations for sub-reach 4c are much lower than for sub-reach 4a. Moreover, the recent review of environmental flow requirements for the lower Loddon River did not specify flow magnitudes for sub-Reach 4d.

Some of the justifications for flow components presented in Table 15 are not correct. For example, winter low flows are not expected to trigger Murray Cod movement. The TRG recommend that all of the flow recommendations reported in the EWP be checked against the relevant source documents to ensure they are accurate.

Estimating flow reductions in different seasons

Tables 19 and 20 summarise expected reductions in flow at different locations in different seasons. The use of summer months and winter months as column headings is confusing because the data presented in each of these columns relates to a six month period, rather than December to February and June to August respectively. The assessments of summer and winter months could probably be removed altogether because outfalls are only going to affect streamflow during the irrigation season. Averaging these changes across summer and winter seasons that include a mixture of irrigation and non-irrigation season months will mask some of the effects of reduced channel outfalls. If the summer and winter categories are going to be retained, then the months that each period refers to should be noted.

The discussion of the patterns presented in Tables 19 and 20 does not appear to be consistent between reaches. The language of the report suggests that small percentage changes in flow in Reach 5 are as significant as larger percentage changes in Reach 4. While this may be true, it needs to be supported by a broader discussion such as the ephemeral versus permanent nature of flow in each reach.

Incorrect cross references within the text

Some of the cross references to figures in the text are not correct. For example, the reference to Figure 5 on page 26 should refer to Figure 4. All cross references should be checked throughout the document.

Wording in tables assessing the dependency on mitigation water

Tables 21 and 22 summarise the arguments for and against mitigation water in each reach of the Loddon River. These arguments are based on criteria that must all be met in order for mitigation water to be deemed unnecessary. The wording used for each of these assessments is confusing. We suggest that the words “Yes” and “No” should be omitted from these tables and the text be simplified to a simple statement that describes the relevance of each criteria to that reach.

Incorrect calculations of the mitigation water commitment

The EWP describes and adopts a six step process for calculating the volume of mitigation water required in each Reach of the Loddon River. Step 5 is supposed to calculate the mitigation water commitment based on the frequency that outfall water is likely to meet an environmental need. For example, if outfalls were considered to contribute to summer freshes, and summer freshes were needed every year, then all of the outfall water would be considered necessary and the commitment would be 100%. In the draft EWP the mitigation water commitment is described as the proportion of outfall water that enters the Loddon River after allowing for losses. These calculations should be repeated to correct the error.

3. Specific issues related to the Loddon River Reach 4

3.1. The Loddon River between Loddon Weir and the Loddon Fan

The latest review of environmental flows for the lower Loddon River deliberately ranks each of the recommended flow components for the reach between Loddon Weir and Macorna Channel, including Twelve Mile Creek. Bankfull flows and winter low flows are the two most important flow components for these sub-reaches and summer low flows and freshes are not recommended unless the higher priority flow components have already been delivered. Ideally, all of the environmental flow recommendations will be delivered. However, if there is insufficient environmental water in the future then these sub-reaches of the Loddon River will be managed as an ephemeral system.

Channel outfalls between Loddon Weir and the Macorna Channel are not likely to make a significant contribution to high and bankfull flows, but they could be important for sustaining low flows during summer and may also contribute to flow variability. The EWP should highlight the contribution that channel outfalls have made to low flows in these reaches and describe the potential environmental benefits that would have been associated with them.

The EWP argues that the two outfalls that enter Twelve Mile Creek are unlikely to contribute any flow to the rest of the Loddon River and that since there is no hydrological information for Twelve Mile Creek these outfalls are not considered further. The recent review of environmental flow recommendations for the lower Loddon River used models and channel losses to estimate flow in Twelve Mile Creek. It should be possible to perform a similar analysis for the EWP and therefore the lack of hydrological data is not sufficient reason to defer an analysis of Twelve Mile Creek. There are other reasons however for concluding that channel outfalls do not significantly contribute to the environmental values of Twelve Mile Creek. Channel outfalls are not likely to contribute to high flow events, which have been identified as the highest priority for environmental values in Twelve Mile Creek. In fact, channel outfalls are likely to do little more than wet small sections of the reach during summer, which is likely to exacerbate the growth of river red gum and other terrestrial plants in the stream bed. These points should be used instead of the lack of hydrological information to support the recommendation for no mitigation water in Twelve Mile Creek.

Some workshop participants were unclear about the role that the Twelve Mile Creek regulator played in the hydrology of the lower Loddon River system. A short section should be included in the EWP that clearly states that the structure is not used to deliver or manage channel outfalls.

3.2. Assessment for the sub-reach downstream of Appin South

The EWP uses the environmental flow recommendations for the Loddon River immediately downstream of Loddon Weir as the benchmark for assessing the relative importance of channel outfalls downstream of No. 2 Channel. The Loddon River loses capacity between Loddon Weir and Canary Island due to the large number of distributary channels that carry water onto the floodplain. There are also substantial channel losses along the reach. Downstream of Canary Island, some anabranches and floodplain drainage channels rejoin the Loddon River and the channel capacity increases.

The recent review of environmental flow recommendations for the lower Loddon River did not specify flows for the Loddon River downstream of Canary Island. Rather it indicated that whatever proportion of the flows that were released from Loddon Weir to meet the objectives in Reach 4a should be adequate to meet the environmental requirements near Appin South. Having said that, the environmental flow review did recognise that flow in the Loddon River downstream of the Loddon Fan should become more permanent and recommended that flows may need to be released from Macorna Channel to help maintain water quality and habitat in the upstream sections of the Kerang Weir pool. Any flow in the Loddon River downstream of Canary Island is likely to contribute to flows further downstream. Channel outfalls through this reach should therefore be considered in the context of how they contribute to flows further downstream rather than asking how they contribute to a flow regime recommended for Reach 4a.

In doing this assessment, two potentially negative impacts of channel outfalls should also be considered. First, channel outfalls may exacerbate the growth of river red gum and other terrestrial vegetation in the bottom of the channel, which has become a problem near Appin South in recent years. Second, water draining the floodplain near Appin South has the potential to carry high salt and nutrient loads to the river. Water quality issues, particularly threats associated with high salinity, should be discussed more broadly throughout the EWP

4. Specific issues related to the Loddon River Reach 5

4.1. Contribution of channel outfalls to summer low flows and flow variability

The importance of channel outfalls in providing flow variability and potentially contributing to summer low flows and summer freshes in the Loddon River downstream of Kerang Weir should be discussed in more detail in the EWP. The importance of channel outfalls in contributing to summer flows may become more important in the future and may already be more important than in the baseline year of 2004/05 because much less water passes over Kerang Weir now. In 2004/05 approximately 100 ML/day passed over Kerang Weir for most of the irrigation season. Current flows are much lower than that and can be zero. These points should be highlighted and may build on the discussion of the relevance of the baseline year reference point described earlier.

The TRG discussed the need for mitigation water if the recommended environmental flows for the reach are delivered in full. The recent review of environmental flows for the lower Loddon River indicated that the fish community and other environmental values in the Loddon River downstream of Kerang Weir had until recently been supported by high flows during the irrigation season and therefore summer flows in excess of the recommended environmental flows would probably benefit these communities. The TRG agreed that flows in excess of the recommended summer environmental flows would probably be good, but they could not be sure that the contribution of channel outfalls on top of the recommended environmental flows would deliver a better environmental outcome. The TRG did however suggest that if mitigation water was delivered, there may be benefit in releasing it from Macorna Channel so that it could improve the condition in the reach immediately upstream of Kerang before it passed over Kerang Weir.

4.2. Estimation of outfall losses

The calculations presented in Section 7.2 indicate that only 1,501 ML out of the 1,860.5 ML of channel outfall water entered Reach 5 of the Loddon River in the Baseline year. The difference is attributed to losses between the outfall location and the river channel. However, most of the channel outfalls downstream of Kerang Weir are very close to the river and therefore losses are expected to be minimal. These calculations and numbers should be reviewed.

5. Concluding remarks

The TRG felt that the process for assessing the requirement for mitigation water has some limitations. The Loddon River is flow stressed and any opportunity to retain water in the system should be embraced. The assessment process only allows for mitigation water if the outfalls, as they are currently delivered, provide a demonstrable benefit to the environment. If mitigation water is deemed necessary then it can be delivered to the river in any way that maximises the environmental outcomes. However, it is not possible to secure mitigation water on the basis that it would provide an environmental benefit if it was delivered in an appropriate way.

The feedback provided here represents the views of the TRG and is based on the draft EWP. We envisage that the information provided will help the NCCMA apply an appropriate level of scientific rigour to the final EWP.

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Appendix H: Water quality analysis for the Loddon River EWP

A brief assessment of the water quality within the Loddon River and the Irrigation system is provided below.

Step 3 of the Mitigation Water Assessment includes a criteria that states:

"Mitigation water may be assessed as zero where the wetland or waterway receives water from the irrigation system; Criteria 2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values".

Table H1 provides a summary of key water quality monitoring sites that provide a representation of the water quality within the Irrigation system and the Campaspe River.

Table H1: Loddon Water Quality Data

Water Quality Monitoring Site	Median Electrical Conductivity Us/cm (No of samples)	Median Total Nitrogen Mg/l (No of samples)	Median Total Phosphorus Mg/l (No of samples)
Loddon River Reach 4			
Loddon River @ Serpentine Weir (407229)	1500 (90)	0.75 (181)	0.033 (179)
Waranga Basin @ Head Gauge (405260)	86 (166)	0.40 (166)	0.026 (166)
Loddon River Reach 5			
Loddon River @ Kerang (407202)	310 (349)	0.7 (1000)	0.1345 (974)
Murray River @ Torrumbarry (409207)	89 (493)	0.49 (1299)	0.061 (1291)

Water Quality Data: obtained from the Victorian Water Resources Data Warehouse http://www.vicwaterdata.net/vicwaterdata/home.aspx

Loddon River Reach 4

The Waranga Basin site (405260) is used as water is supplied to the Pyramid Boort Irrigation area from the Waranga Western Channel via the Waranga Basin. The Loddon River at Serpentine (407229) has been used to represent the water quality within the River. It has been assumed that water quality has not changed significantly where outfall water enters a drain prior to entering the Loddon River.

It is clear from Table H1 that water quality within the Pyramid Boort irrigation system is of better quality to the water in the Loddon River and therefore outfall water is not detrimental to the environmental values of the Loddon River (Refer to Table 23 in Section 8 Mitigation Water Assessment.

Loddon River Reach 5

The Murray River at Torrumbarry site (409207) is used as water is supplied to the Torrumbarry Irrigation area from the Murray River via the Torrumbarry Weir. The Loddon River at Kerang (407202) has been used to represent the water quality within Reach 5 of the Loddon River. It has been assumed that water quality has not changed significantly where outfall water enters a drain prior to entering the Loddon River.

It is clear from Table H1 that water quality within the Torrumbarry Irrigation System is of better quality to the water in the Loddon River and therefore outfall water is not detrimental to the environmental values of the Loddon River (Refer to Table 29 in Section 8 Mitigation Water Assessment.

Appendix I: Environmental flow monitoring

There is already an ongoing environmental flow, water resource planning and water quality monitoring program for the Loddon River conducted by the North Central CMA and Goulburn-Murray Water. This monitoring program is seen as sufficient and will be used to inform the outcomes of the use of mitigation water.

I1: Long-term condition Monitoring - VEFMAP

The Victorian environmental flows monitoring and assessment program (VEFMAP) is aimed to:

"Evaluate ecosystem responses to environmental flows in the eight high-priority regulated rivers that are to receive enhancements to their flow regime".

This study aims to achieve:

- A consistent, scientifically defensible, framework for monitoring environmental flows in pre-defined regulated rivers across Victoria.
- Detailed, hypothesis based, monitoring plans for each specific river where the delivery of environmental flows is expected or underway.
- Sufficient flexibility in the monitoring framework and plans so that they can be adapted in light of changing conditions and information generated by the on-going data analyses.

The Loddon River was selected for this statewide program. The monitoring programs implemented include:

- Physical habitat and geomorphology
- Water quality monitoring
- Fish, aquatic and riparian vegetation assessments

I2: Intervention Monitoring

Currently (Temporary Qualification of Rights), environmental flow releases are made in response to perceived ecological risks:

- Stratification and/or deoxygenation of bottom layers of water, especially in pools
- Blue-green algae outbreaks
- Fish deaths

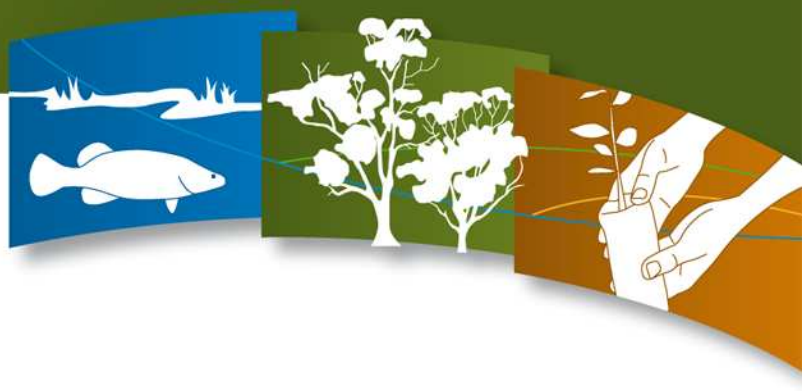
Environmental flows are released based on an assessment of the monitoring data and the water availability. The current maintenance of water quality conditions is based upon a set of trigger levels which aim to keep the water quality above a threshold at which fish can survive. Trigger levels for water quality have been set by scientific panel advice (Humphries 2006).

When it is expected that environmental degradation will occur, for example, a trigger level has been reached or there is a downward trend in water quality toward the trigger level, the North Central CMA advises Goulburn-Murray Water to release an environmental flow. Goulburn-Murray Water is responsible for releasing flows conditional upon the volume being available in the reserve for environmental purposes.

The management of environmental flows is highly adaptive and dynamic in response to environmental conditions and system operation constraints (NCCMA 2009b). Refer to Table I1 for site locations and monitoring techniques undertaken.

Table I1: Water quality monitoring sites - location and rationale

River / Reach	Site location	Features / Rationale	Monitoring Technique
Reach 4: Loddon Weir – Kerang Weir	**1.** Borung-Hurstwood Rd	• Existing monitoring site • Deep pool • Cross reference for continuous water quality logger	• G-MW water quality monitoring • Continuous probe
	2. Borung-Fernihurst Rd / No.2 Weir Road	• Existing monitoring site • Deep pool	• G-MW water quality monitoring
	3. Boort-Pyramid Rd	• Existing monitoring site	• G-MW water quality monitoring
	4. Yando Swamp Rd	• Existing monitoring site	• G-MW water quality monitoring • Continuous probe
	5. Appin South	• Existing monitoring site	• G-MW water quality monitoring
	6. Gilmore Lane	• Existing monitoring site • Deep pool - backed up from Macorna Main Channel	• G-MW water quality monitoring
Reach 5: Kerang Weir – Little Murray River	• Not part of the Environmental Flow Management Program. Once operational rules for Loddon River Reach 5 are agreed, sites will be added to this program.		



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