# Development of a Rehabilitation Plan for the lower Thomson and Macalister Rivers

## A Scoping Study

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Technical Report
5/2001

Cooperative Research Centre for Freshwater Ecology

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COOPERATIVE RESEARCH CENTRE FOR
FRESHWATER ECOLOGY

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CATCHMENT HYDROLOGY

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## Executive Summary

A Rehabilitation Plan is to be developed for the lower Thomson and Macalister Rivers that when implemented will improve river condition by optimising the interaction between environmental flows and aquatic habitat management. The rehabilitation plan is to be developed in two stages: a scoping stage and an investigative works stage. This report summarises stage one (Scoping stage), and outlines:

- The available information that describes the ecological and physical condition of the study area;
- The basis for rehabilitation, including a vision for the system and key objectives for rehabilitation;
- Gaps in our understanding of the system;
- What rehabilitation actions can be implemented now; and
- An investigative works program that will provide additional information to guide the development of a rehabilitation plan for the lower Thomson and Macalister rivers.

The conceptual framework used to developed the plan involved:

- Developing a vision for river system;
- Defining the key attributes of the river to be considered for future rehabilitation or protection;
- Assessing the current condition of the rivers (in terms of key ecological attributes) and how conditions have changed since European settlement;
- Considering the information required to develop or quantify future rehabilitation targets;
- Identifying the actions required to fill knowledge gaps and rehabilitation measures that may continue while the rehabilitation plan is finalised (i.e. actions we are confident will have a high chance of success);
- Considering the monitoring and assessment initiatives required to measure whether rehabilitation targets are met in the future.

**What is the present condition of the river system?**

While it is clear that many attributes of the river systems have changed since European settlement, the effects of these changes on ecological processes  largely unknown. Some of the key factors that may affect the ecology of the river include:

- Less water or changes to the timing of flows required to support ecological processes;
- Decreased native fish abundance and distribution;
- Fewer than expected number of macroinvertebrate families in some river reaches;
- A decline in aquatic vegetation diversity and abundance;
- A decline in water quality, especially in lower reaches of the river system;
- Changes to natural geomorphological processes that may alter the pace of natural channel evolution and habitat diversity;
- Loss of riparian vegetation diversity, continuity and area; and
- Decreased area, number and quality of wetlands.

**Key issues for rehabilitation**

A vision for the river system was developed after consultation with an Advisory Group established for the scoping study. The vision is to:

"*Provide a healthy ecosystem with diverse habitats (aquatic and terrestrial), communities and species, and an environmental flow regime that will sustain native flora and fauna. The river system will be one that people can access and enjoy, that supports a diverse landscape with multiple uses and values, and is consistent with community values and expectations*".

This vision has both ecological and socio-economic aspects and it is recognised that the two are closely linked. In this report we focus on the ecological objectives and targets, which are:

- The maintenance of in-stream conditions that will support predominantly native flora and fauna;
- Channel evolution that increases physical habitat diversity, especially in Rainbow Creek;
- Riparian vegetation that is dominated by native species, and is continuous along the river and onto the floodplain;
- A river system that has adequate flow connections with the floodplain and associated wetlands.

The changes that have occurred in the river system since European settlement can be used to set *directional* targets (rather than *end points*) for rehabilitation. It should be recognised that the extensive modification to the river and floodplain system in the study area means that setting pre-European conditions as rehabilitation targets (*end points*) is unrealistic; it is unlikely that the river system could ever be returned to a pristine state. Rehabilitation efforts that focus on achieving a partial return of structure and function lost to disturbance are far more realistic when trying to improve environmental conditions.

The major changes thought to have occurred in the river system since European settlement are summarised in Section 4.2. These key issues provide a basis for setting rehabilitation targets and also for evaluating whether implementation of a future rehabilitation plan is successful (i.e. performance monitoring).

We recommend that the rehabilitation targets for both the Thomson and Macalister Rivers include:

- Sufficient volume and timing of flows available to support key ecological processes;
- Increased native fish abundance and distribution;
- Increased number of macroinvertebrate families in reaches where there are fewer families than expected;
- Increased diversity and abundance of native aquatic vegetation along the river;
- Improved water quality along the river system;
- Geomorphological processes that are largely natural to help promote physical habitat diversity;
- Increased native riparian vegetation diversity, continuity and area;
- Increased area, number and quality of wetlands associated with the river system.

Investigations to quantify the above targets will be a critical part of Stage 2 of this project.

**What actions are needed?**

Our preliminary analysis suggests that the rehabilitation plan should focus on the following key issues:

- Assessment of the ecological importance of changes to the flow regime (e.g. reduced frequency of medium sized flow pulses - up to 10,000 ML/d in the Thomson River - and the need for increasing the frequency of such flows);
- Attention to improving in-stream habitat;
- Attention to improving riparian vegetation (programs already exist for this and should be continued);
- Attention to water quality issues (programs already exist for this and should be continued);
- Reconnection of river channels to their floodplains and associated wetlands;
- Development of a performance assessment program to measure the success of future rehabilitation efforts.

## Acknowledgements

Thank you to Gary Howell, Bill Hansen and Jane Doolan (DNRE), who provided very fruitful discussions and advice. A thank you is also extended to the members of the Advisory Group who helped to develop a vision for the river system that will guide future rehabilitation efforts. The Advisory Group included:

Ken Bates (Southern Rural Water), Jo Caminiti (West Gippsland CMA), Jack Dwyer, Heather Farley (EPA Victoria), Brian Frawley, Bill Hansen (DNRE), Eleisha Keogh (DNRE), Ross Scott, Mal Spears (Melbourne Water).


## Acronyms used in this report

| | |
|---|---|
| AHD | Australian Height Datum |
| COAG | Council of Australian Governments |
| CRCFE | Cooperative Research Centre for Freshwater Ecology |
| CRCCH | Cooperative Research Centre for Catchment Hydrology |
| CSF | Cascading Seasonal Flows |
| DNRE | Department of Natural Resources and Environment |
| DRIFT | Downstream Response to Intended Flow Transformations |
| EPA | Environment Protection Authority Victoria |
| FEM | Flow Events Method |
| MID | Macalister Irrigation District |
| MOU | Memorandum of Understanding |
| MW | Melbourne Water |
| SEPP | State Environment Protection Policy |
| SRW | Southern Rural Water |
| WGCMA | West Gippsland Catchment Management Authority |

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# 1 INTRODUCTION

The Department of Natural Resources and Environment (DNRE) established the Stressed Rivers Program in response to the COAG Water Reform Agreement and as part of its River Health Initiative. A Reference Panel was set up to develop criteria for identifying and prioritising flow-stressed rivers in Victoria. The Reference Panel identified the Thomson River below Cowwarr Weir as high priority for rehabilitation. Subsequent work has identified that the Macalister River is likely to be flow-stressed (CRCFE 1999) and the river has been included in this study in recognition of its contribution to environmental flows in the lower Thomson River, and its importance in the Bulk Entitlement process and for providing irrigation water to the Macalister irrigation district.

A River Rehabilitation Plan is to be developed that when implemented will improve the condition of the lower Thomson and Macalister Rivers by optimising the interaction between environmental flows and aquatic habitat management. The development of a plan is consistent with the recommendations of the CRC for Freshwater Ecology (CRCFE) assessment of environmental flow requirements undertaken for the West Gippsland Catchment Management Authority (CRCFE 1999), and that of Gippel *et al.* (1993).

Previous assessments of flow and habitat condition in the lower Thomson and Macalister Rivers have identified a number of gaps in our understanding of the effects of flow and catchment management on ecological processes, including key drivers of river health such as water quality and habitat availability (CRCFE 1999; Gippel *et al*. 1993; Mulapatil and Blythe 1982). This project seeks to clarify what is known of the important environmental values and ecological processes of the Thomson and Macalister Rivers and how river management affects them. It also presents rehabilitation objectives and targets, and identifies rehabilitation actions that can be implemented immediately, and recommends additional investigations to provide further information for the rehabilitation plan as it is developed. This information is essential if future rehabilitation works are to improve the integrity of the river system.

## 1.1 The Agreement on an Environmental Flows Package for the Thomson and Macalister Rivers.

Negotiations for the Bulk Entitlement Conversions for Southern Rural Water and Melbourne Water in the Thomson and Macalister River Basins resulted in an agreement on an Environmental Flows Package. The main objective of the Environmental Flows Package was to address the concerns raised in the Environmental Assessment for the Lower Thomson and Macalister Rivers, undertaken by the CRCFE in 1999.

However, the Environmental Flows Package goes further than implementing the recommendations of the CRCFE report; it recognises that sustainable management of flows in the Thomson and Macalister Rivers requires an integrated approach. To this end a Taskforce has been established to oversee and coordinate the implementation of the Environmental Flows Package. The Taskforce has broad terms of reference that include considering findings and recommendations from other studies and recommending additional work required to achieve implementation of the Agreement.

The Taskforce has identified this Stressed Rivers Restoration Plan as a key project addressing the issue of adequate environmental flows in the Thomson and Macalister Rivers. The Taskforce expects that some of the outcomes of the Scoping Study will provide direction for implementating many of the items from the Environmental Flows Package. In particular the establishment of Ecological Management Objectives and the identification of knowledge gaps will guide the implementation process.

## 1.2 Thomson-Macalister stressed river rehabilitation plan objectives

The project brief identified the following objectives for a Stressed Rivers Restoration (Rehabilitation) Plan for the Thomson River below Cowwarr Weir and the Macalister River below Lake Glenmaggie:

- To develop draft environmental management objectives for the Thomson and Macalister Rivers, derived from an examination of the environmental values for this system.
- To relate these environmental values and management objectives to a suite of flow objecties and complementary objectives for habitat and water quality rehabilitation in the Thomson and Macalister system.

The recommended flow regimes are to be within the range of outcomes that are feasible within the constraints of the Thomson/Macalister water supply system. Future environmental flows are likely to be delivered as a stepped progression towards an optimal flow regime. It is important that there is a clear understanding of the part of the flow regime is being targeted and the associated environmental benefits. The actual trade-offs involved in moving from the present flow regime to a more ecologically sustainable regime will be undertaken as part of a separate Bulk Entitlements process.

The development of a rehabilitation plan for the Thomson and Macalister Rivers is to be conducted in two stages (Figure 1): a scoping stage and an investigative works stage. This report documents stage one (Scoping stage), and outlines:

- The available information that describes the ecological and physical condition of the study area;
- The basis for rehabilitation, including a vision for the system and key objectives for rehabilitation;
- Gaps in our understanding of the system;
- The rehabilitation actions that can be implemented now; and
- An investigative works program that will provide additional information to guide the development of a rehabilitation plan for the lower Thomson and Macalister rivers.

The investigative works program (a ‘map’ for Stage 2) recommends key ecological processes to be investigated, timeframes, estimated costs and priorities for action.

This scoping study involved discussions with key community stakeholders to develop a common vision for the future condition of the river system, to ensure that rehabilitation objectives are clear, and to recognise other relevant activities occurring in the study area. This process was largely based around an Advisory Group workshop, attended by representatives from DNRE, West Gippsland Catchment Management Authority (WGCMA), Environment Protection Authority (EPA), Southern Rural Water (SRW), Melbourne Water (MW) and local landholders.

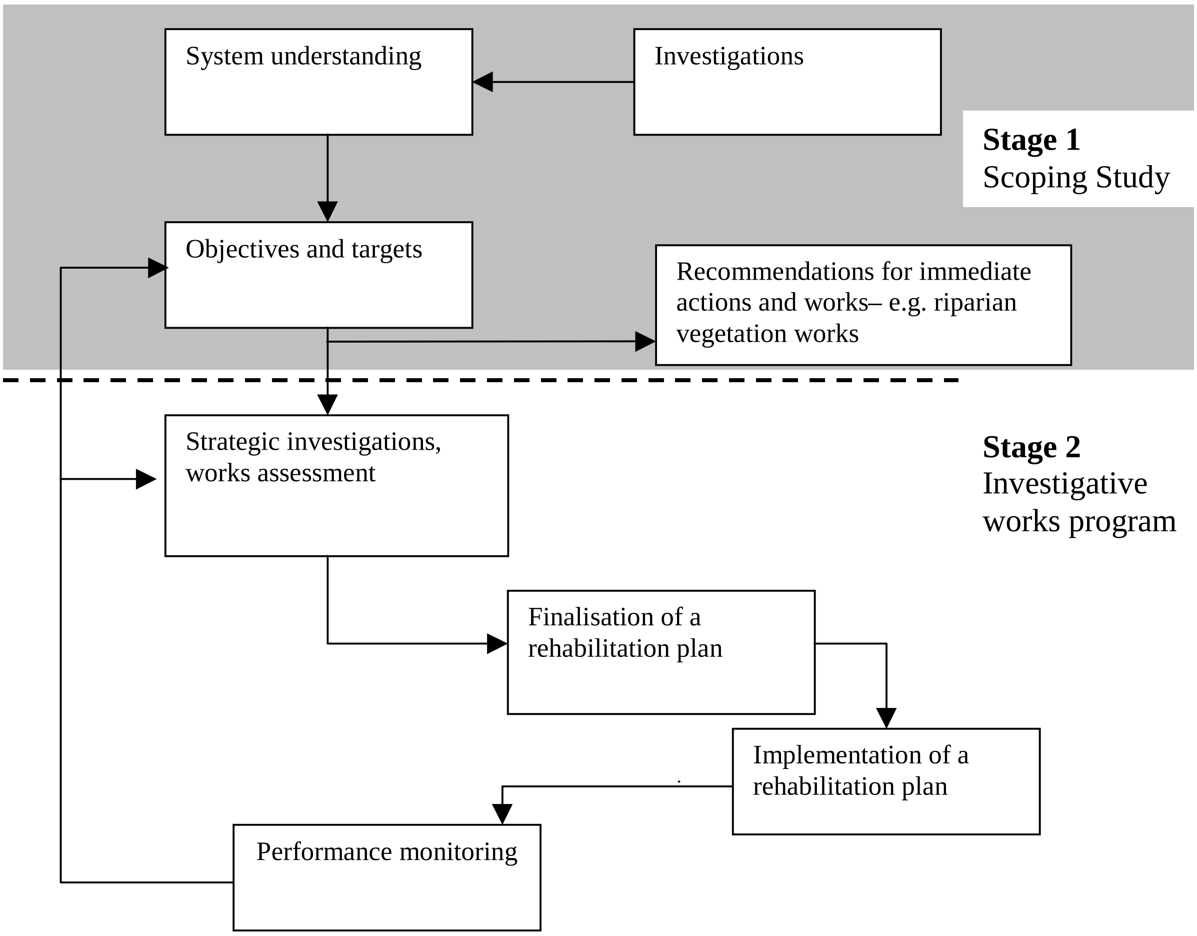



**Figure 1: Development of a River Rehabilitation Plan for the lower Thomson and Macalister Rivers**

## 1.3 Study Area

The Thomson - Macalister River systems have a combined catchment area of 3,660 km$^2$, or 17.4 % of the Gippsland Lakes catchment, and drain the South Eastern Highlands of Australia. The drainage of the Thomson extends from Mt Gregory (3196 m AHD) to Sale where it joins the Latrobe River. The Macalister (catchment area of 2,330 km$^2$) drains an area from Mt Tamboritha (5478 m AHD) across to Mt MacDonald (5315 m AHD) and down to the Thomson River. The study area includes the Thomson River below Cowwarr Weir (including Rainbow Creek) to the Latrobe River confluence, and the Macalister River below Lake Glenmaggie to the Thomson River confluence (Figure 2).

## 1.4 Structure of the report

Chapter 2 of this report outlines the conceptual approach necessary to develop a rehabilitation plan to address flow-related ecological issues in the lower Thomson and Macalister Rivers. Important State, regional and local water-resource management programs complementary to a rehabilitation plan are considered in Chapter 3. Chapter 4 summarises changes to the ecological conditions in the lower Thomson and Macalister rivers since European settlement. A vision for the river system, as well as ecological objectives and targets required for meeting the vision, are presented in Chapters 5. This chapter also summarises the actions that should provide information for the development of a rehabilitation plan. Chapter 6 outlines aspects of a program for performance monitoring that will ensure objectives are met when the rehabilitation plan is implemented are outlined in Chapter 6.

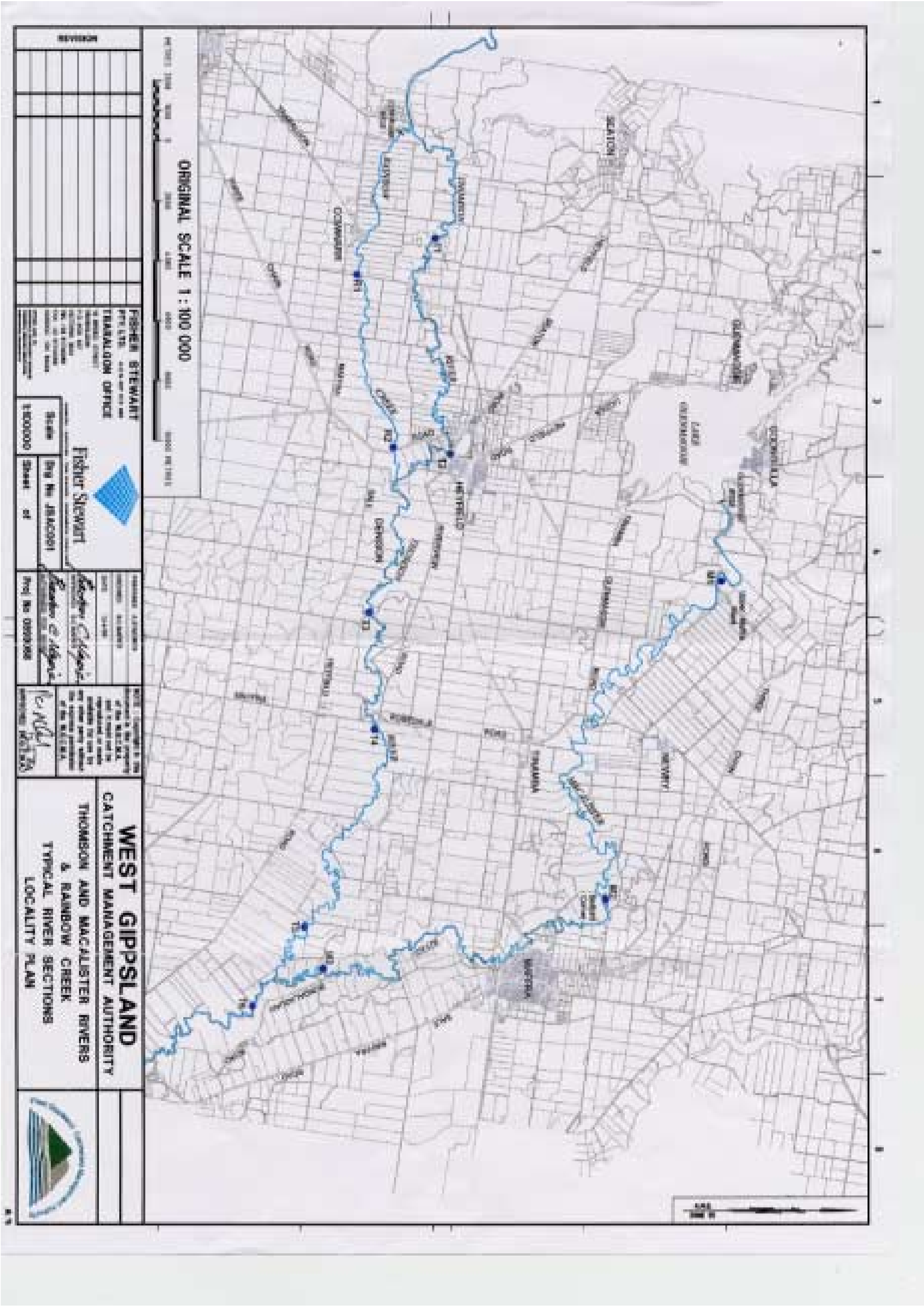



**Figure 2: Lower Thomson and Macalister Rivers study area**

## 2 CONCEPTUAL FRAMEWORK FOR REHABILITATION

Three key factors (or drivers) control the condition of a river ecosystem:

- Flow regime;
- Physical structure of the river, including habitat for biota; and
- Water quality.

They influence the ecology of rivers by, for example:

- Providing breeding cues for fish;
- Maintaining suitable physical habitat conditions;
- Linking the river channel with riparian, wetland and floodplain habitats;
- Sustaining aquatic biota (e.g. dissolved oxygen that sustains respiration).

All three factors must be considered (Figure 3) to ensure that rehabilitation addresses the underlying causes of degradation (see discussion in Appendix 1) and is ultimately successful. Rehabilitation plans that focus on only one of the key drivers are unlikely to be successful; a successful rehabilitation plan must link the three drivers. For example, major environmental gains will not occur from additional environmental flows unless there is adequate in-stream habitat.

This report concentrates particularly on flow rehabilitation, because existing resource management plans pay little attention to this issue, despite these two rivers being highly regulated. Current plans mainly focus on water quality and the management of riparian vegetation. The development of flow rehabilitation plans is hampered at present by generally poor knowledge about flow-related ecological issues in most Australian rivers, including the Thomson and Macalister rivers.

While ‘river improvement’ efforts have been widespread across Australia for many decades, it is only recently that general principles have been developed to help guide rehabilitation and assist with the transfer of methodologies from one area to another (Hobbs and Norton 1996, Kirshner 1997; Rutherfurd *et al.* 1998). Successful rehabilitation projects generally have clear objectives, consider the underlying causes of degradation so that remedial actions are appropriately targeted, and include an assessment program to ensure that objectives have been met once rehabilitation measures have been implemented.

A good understanding of the key processes that control stream condition is highly desirable in establishing a successful rehabilitation program. Our knowledge is good in some areas. For example, well established and successful techniques are available for rehabilitating and managing riparian vegetation and for treating polluted water. However, in other areas of river rehabilitation there is a great uncertainty, so the assumptions about both the condition of the river system and the degrading processes have to be clearly identified and critically examined. It is then possible to identify those aspects of rehabilitation that are based on sound scientific knowledge and those that are ‘best bet’ or require additional investigations. It is well to recognise that managers will have to make decisions on the basis of less than adequate knowledge for some time yet. In these cases, best practice requires that the uncertainties are clearly identified and investigations (or research) are put in place to provide the knowledge that reduces these uncertainties.

Most rehabilitation activities can be considered as experiments, with the rehabilitation plan based on assumptions that certain actions will result in improvements in the ecological condition of the river. It should be recognised that the processes that lead to degraded river systems may occur over time frames ranging from days (e.g. discharge of pollutants) to years (e.g. land degradation; salinity effects). Equally, in cases where degrading processes are widespread and persistent, it is highly likely that the effect of rehabilitation efforts will take many years to become apparent. It is also possible that river condition will continue to decline for some time, even after rehabilitation works have been started (Figure 4). A robust monitoring program will be required to assess whether the improvements expected from rehabilitation efforts are in fact being achieved. If the expected improvements are not occurring, changes in the river management will be required. This whole process is an example of adaptive management.

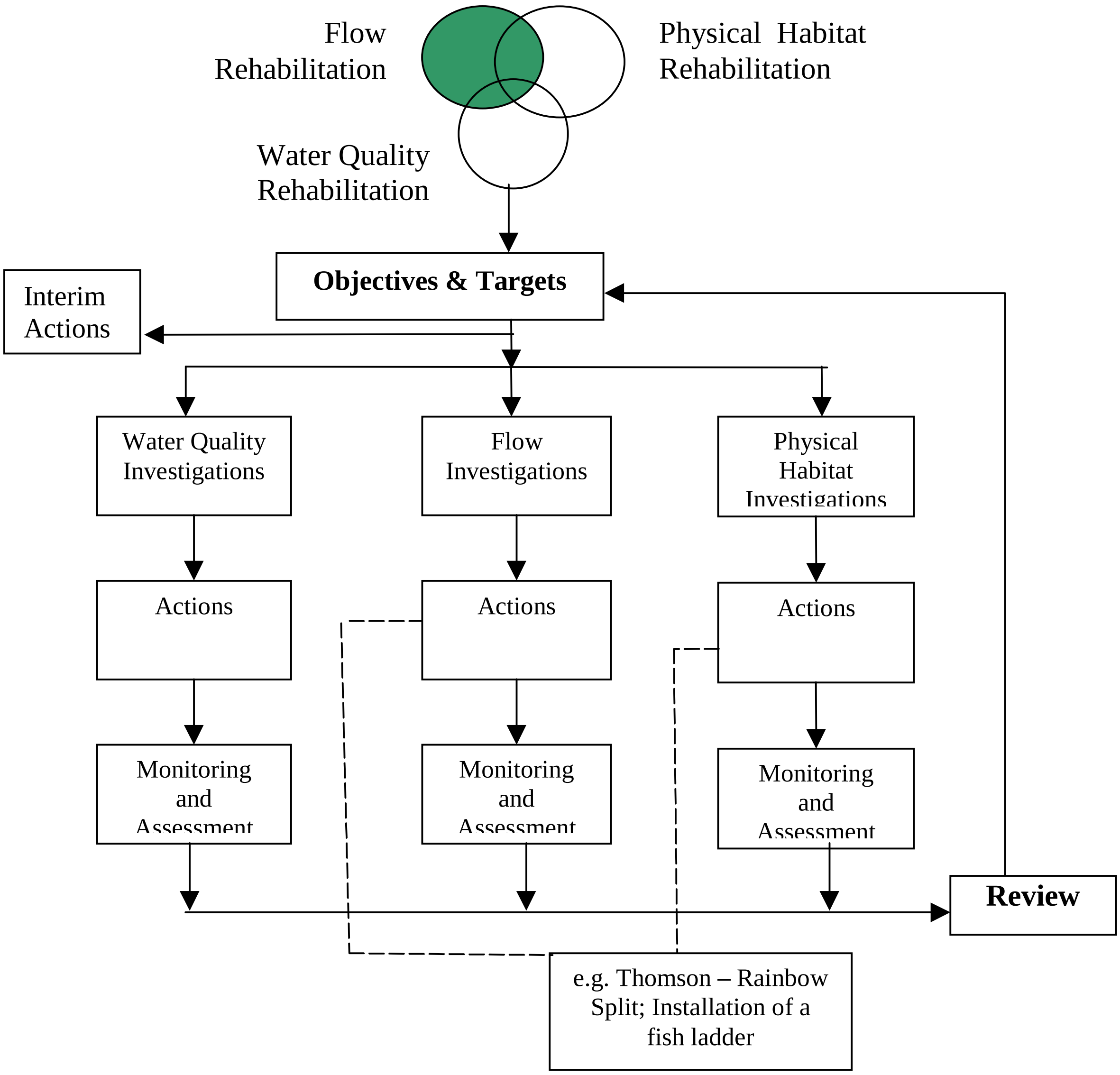



**Figure 3: Conceptual approach to developing a rehabilitation plan. Note the emphasis is on flow rehabilitation and those aspects of water quality and physical habitat rehabilitation that may be affected by flow.**

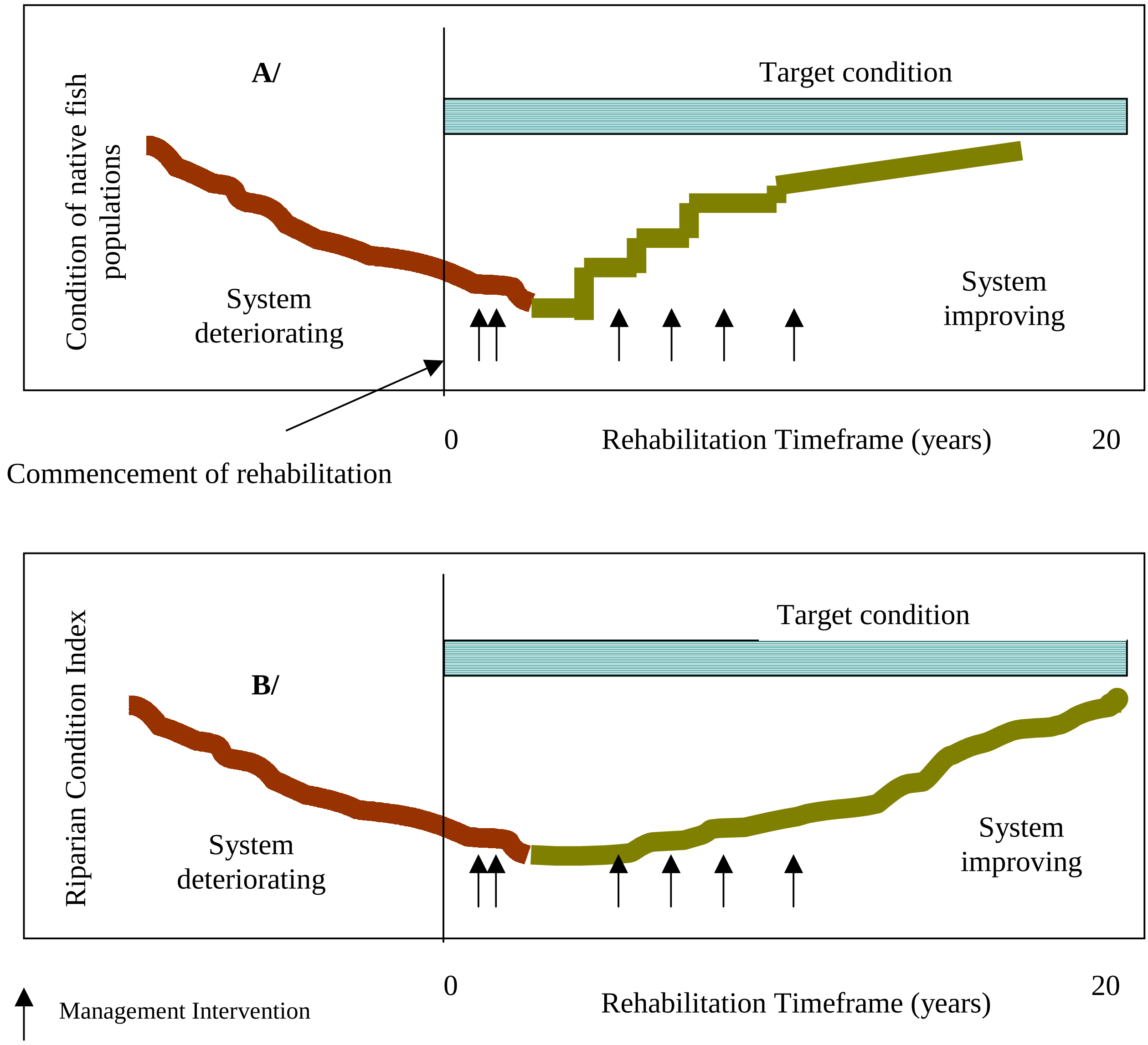



**Figure 4: Possible degradation and recovery in response to rehabilitation efforts for native fish (A) and the riparian zone (B). Note: recovery is compared with a reference condition representing some desired state. Target and rehabilitation site condition are represented by bands, recognising that conditions will vary naturally within each band.**

## 2.1 What will a rehabilitation plan for the Thomson and Macalister Rivers contain?

The Thomson and Macalister rehabilitation plan should contain:

- A An introduction that provides the context in which the rehabilitation plan has been prepared.
- B A vision statement that expresses the aspirations of all stakeholders for the study catchment, including the river system and associated wetlands in question.
- C A short description of the study area, along with an assessment of current river condition and identification of the underlying causes of river degradation (degrading

processes); Identification of linkages with other resource management plans or initiatives to ensure an efficient and coordinated approach to rehabilitation.

D Identification of linkages with other resource management plans or initiatives to ensure an efficient and coordinated approach to rehabilitation.

E A statement of rehabilitation objectives (or targets) that addresses the underlying causes of river degradation and provides a means by which the overall vision for the system is attained.

F An evaluation of the options available for ameliorating the underlying causes of river degradation.

G An evaluation of the options or techniques (e.g. reinstatement of fish passage, provision of ecologically important flows, resnagging) available to rehabilitate key components of the riverine ecosystem (i.e. once the underlying causes of degradation have been removed), including an assessment of the relative importance of each option in terms of meeting rehabilitation objectives, likely success and cost.

H An implementation plan that includes priorities for action, the budget required to undertake actions, and agreed responsibilities for action.

I A monitoring and assessment plan to evaluate the success of the rehabilitation plan and identify how new information will be fed back into the decision making process.

The nine steps above outline the development of a shared vision for the future of the river system; the visiion identifies environmental values to be protected or enhanced. Consideration of changes to the system in recent times, and the factors that have influenced the changes, provides a sound basis for defining rehabilitation targets, setting priorities, developing techniques for action, and identifying appropriate measures of the success (or failure) of actions taken to rehabilitate the river.

The key steps used in this study to provide information for developing the Thomson-Macalister rehabilitation plan included:

- Definition of the project boundaries;
- Development of a conceptual model of the key drivers of river health for the particular system;
- Collation of information (hydrological, geomorphological and ecological) and an assessment of how conditions may have changed since European settlement;
- Collaboration with stajeholders to develop a vision for the future condition of the river system with the community/stakeholders;
- Development of acceptable rehabilitation objectives and targets;
- Identification of the key knowledge gaps that must be addressed in order to develop a rehabilitation plan that has a high likelihood of success;
- Identification of rehabilitation actions (these may include on-ground actions or focused investigations to provide further knowledge);
- Definition of the key components of a monitoring program to measure the success of rehabilitation efforts.

Steps A to D of the rehabilitation plan framework listed above (i.e. statement of context, vision and current conditions) have been completed. Step E, the statement of rehabilitation objectives and targets, has been partly completed; the objectives have been identified but rehabilitation targets require quantification (a key part of stage 2 of this project). Step F (options for minimising sources of underlying degradation) has been partly completed. Completion of this step requires further investigations related to key ecological interactions.

Step G (confirmation of specific rehabilitation options and cost-benefit analysis) has been partially completed (e.g. continued implementation of the WGCMA native vegetation plan); additional options will become apparent upon completion of the additional investigations recommended in Chapter 5. Step D (linkages with other initiatives) will require review as additional rehabilitation actions are confirmed and stakeholders agree to responsibility for implementation.

A process for Step H, the development of an implementation plan for the lower Thomson and Macalister Rivers, has yet to be formalised. This is an essential step to coordinate the input of new information, gain agreement on further rehabilitation activities, and implement the performance monitoring program identified in Step I (see Chapter 6). The performance monitoring program should be finalised once rehabilitation targets have been quantified.

A process is required for coordinating future investigations and finalising the rehabilitation plan. Finalisation of the rehabilitation plan should include consultation with stakeholders via existing networks such as the WGCMA, Landcare Groups and water service committees that liaise with SRW. While the rehabilitation plan will focus on riverine and floodplain issues, it is important to remember that implementing the plan is also expected to provide benefits downstream in the Gippsland Lakes.

# 3 STATE AND REGIONAL PROGRAMS

During the development of a rehabilitation plan for the lower Thomson and Macalister rivers, other relevant management initiatives must be considered. These initiatives range from those based at the National (e.g. National Carp Program, National River Health Program), State level (e.g. Waters of Victoria) and regional level (e.g. Latrobe State Environment Protection Policy - SEPP) and local initiatives (e.g. MID phosphorus reduction directed through the Latrobe SEPP at a subcatchment level). These initiatives are particularly important when setting rehabilitation objectives for the Thomson and Macalister Rivers. A synopsis of important State, regional and local initiatives is presented in Appendix 2.

State-based initiatives such as the SEPP - Waters of Victoria (Government of Victoria 1988), the Flora and Fauna Guarantee Act (1998) and the Victoria River Health Strategy (currently being prepared by DNRE) provide a legislative and management framework to support measures that will ensure the survival of healthy rivers in Victoria. These initiatives broadly define a healthy river, and identify goals and objectives for maintaining river health that can be applied at the State level, recognising that local strategies and plans will be required to meet these goals. Aspects of river health identified by these initiatives were considered when identifying rehabilitation objectives for this study. Most important is the emphasis by the Victorian River Health Strategy on the components of the flow regime (e.g. flood flows, bank full flows, low flows) that are important for maintaining ecological processes in rivers. Defining the components of the flow regime that require protection or reinstatement will be important for optimising environmental flows in the future (see Chapter 5).

Initiatives such as the Latrobe SEPP (EPA 1996) and the West Gippsland Regional Catchment Strategy are important programs that implement State-based policy at a regional and local level. These initiatives identify regional goals for river management (i.e. across a number of catchments), key regional and local priorities for management (e.g. salinity, eutrophication, biodiversity, pest plants and animals) and objectives that, when attained, will maintain river condition, so that important beneficial uses of water and riverine resources may continue on a sustainable basis. For the Thomson and Macalister rivers, the following seven beneficial uses are to be protected (EPA 1996):

- Maintenance of natural aquatic ecosystems;
- Potable water supply;
- Water based recreation;
- Agriculture water supply;
- Fishing and aquaculture;
- Industrial water supply; and
- Aquifer recharge.

The West Gippsland Regional Catchment Strategy objectives (WGRC&LPB 1997) has set objectives for water, flora, fauna and fisheries, habitat and conservation; and pest plants and animals, as listed here:

- Water:
  - To protect and improve water systems, water quality and aquatic ecosystems
  - To balance the competing demands on water resources
- Flora, Fauna and Fisheries:
  - To retain the indigenous native diversity
  - To restore threatened species to sustainable levels
  - To protect and recreate integrated habitat and connections

  - To maintain and improve ecosystem balance
  - To balance tourism and recreational use and enjoyment with ecosystem maintenance
- Habitat and Conservation:
  - To identify existing resources and ecosystem requirements
  - To identify and manage specific threats
- Pest Plants and Animals:
  - To significantly reduce the impact and incidence of pests on flora, fauna and primary production
  - To promote and coordinate effective and environmentally sound methods of control.

Meeting the above objectives will require the protection and enhancement of current environmental values associated with the river system (see Chapter 4). However, initiatives such as the West Gippsland Regional Catchment Strategy generally do not identify local priority issues for management (e.g. along a river or tributary reach) or actions to address these issues. An exception is the MID Nutrient Management Plan, which has been developed to help meet a Latrobe SEPP target of a 40% reduction in phosphorus loads entering Lake Wellington (EPA 1996).

Along with the MID Nutrient Management Plan, other local (catchment) programs that include river management are the flows package developed as part of the Bulk Entitlement process for the lower Thomson and Macalister Rivers (Environmental Flows Taskforce 2000), and revegetation works being undertaken by the West Gippsland CMA (WGCMA 2000) and local Landcare groups (Appendix 7). Streamflow management plans will also be developed for unregulated streams in the area, but will not be finalised in the near future. These are local initiatives that set priorities for improving riverine water quality and vegetation management at a local level. These programs are important inputs into a river restoration plan, but were set up to achieve other objectives (e.g. the protection of water quality in Lake Wellington, the management of agricultural land) and do not necessarily reflect priorities for rehabilitating flow-stressed rivers at a local level. For example, revegetation works undertaken by Landcare groups aim to provide wildlife corridors between waterways such as the Latrobe and lower Thomson rivers, or address land degradation issues. They will benefit terrestrial and riparian species but may not address the needs of aquatic biota (e.g. provide habitat for fish). Flow-related issues yet to be addressed by existing programs at a local level include the optimisation of (a) flows that are important for the breeding cycles for native biota, and (b) the habitat available for biota such as fish.

The development of a rehabilitation plan for the lower Thomson and Macalister Rivers will provide the focus necessary to address flow-related ecological issues at the local scale and contribute to the commitments of the State and regional programs identified above. For example, as already mentiioned, improvements in water quality are likely to benefit the Gippsland Lakes downstream of the study area. An agreement on an ‘owner’ of the rehabilitation plan will be critical to its success. This will require discussion and negotiation between the major stakeholders such as DNRE, Melbourne Water, the West Gippsland CMA, Southern Rural Water and the EPA.

# 4 CURRENT ECOLOGICAL CONDITIONS OF THE LOWER THOMSON AND MACALISTER RIVERS

Knowledge of the historic condition of the rivers is fundamental to developing a river rehabilitation plan for the lower Thomson and Macalister that delivers lasting benefits. However, assessment of the historical changes in river health is made difficult by the lack of information about most river systems prior to agricultural, urban and water resource development (i.e. baseline information).

## 4.1 Changes to the Thomson and Macalister Rivers since European settlement

Readily available information on river condition in the study area is presented in Appendix 3. This information was used to assess how the system has changed since European settlement and also to help identify rehabilitation targets, or the knowledge gaps that prevent us from setting targets.

Available data suggest that native flora and fauna have changed since European settlement. Many of these changes have resulted from factors other than changes to the flow regime and there is little information available with which to develop or quantify the causal links that may exist between flow regulation and stream ecology. As the effect of flow regulation on ecological and geomorphological processes is largely unknown, further research is required to define the impacts, if any, of changes to the flow regime in each of the Thomson and Macalister Rivers.

### *4.1.1 Thomson River*

Major changes are thought to have occurred in seven main characteristics of the Thomson River system since European settlement:

i. The hydrology of the system has been highly modified, with approximately 50% of the flow removed for agriculture and urban water supply (Figures 5 to 7). While the total flow has been reduced, the pattern of the flow regime is still quite similar to "natural" (Appendix 3). Hydrological changes include:
   - Significantly reduced volume low flows. However, this should now be remedied with the introduction of minimum flow rules (see Appendix 2) that will ensure 125 ML/d or natural in the lower Thomson River.
   - The channel avulsion that resulted in the formation of Rainbow Creek. Although it is the result of natural processes, the avulsion altered the flow regime of the Old Thomson channel. Cowwarr Weir regulates the flow split between the Old Thomson and Rainbow Creek.
   - The frequency of large flow events (i.e. flows greater than approximately 15,000 ML/d) in the Thomson River below Cowwarr Weir has been largely unaffected by regulation (although regulation controls the proportion of flows that go down the Old Thomson and Rainbow Creek).
   - Medium-size flow pulses (i.e. up to 10,000 ML/d) have been significantly reduced in frequency. The importance of medium-size flows to river ecology remains as the largest gap in our understanding of flow-related river ecology in the Thomson-Macalister system and elsewhere.

ii. The geomorphology of the river has been altered due to direct intervention, removal of riparian vegetation and changed land use and associated activity. This has reduced the diversity of in-stream habitat for biota and is likely to have slowed the natural evolution of reaches such as Rainbow Creek.

iii. Riparian vegetation has been modified along all reaches by the clearance of land for agriculture (vegetation clearance and wetland infilling), active snag removal, replanting with willows and access by livestock;
iv. Water quality is poor in the lower reaches, especially in parameters such as phosphorus concentration and turbidity due to the MID and diffuse runoff from agricultural and urban areas.
v. In-stream habitat has been significantly modified since European settlement:
   - Previous river management works and agricultural practices have altered in-stream habitat through active snag removal, replanting with willows and access by livestock. The condition of in-stream habitat in Rainbow Creek is poor. This may have been exacerbated by previous land clearance, which removed potential sources of woody debris from the floodplain before the avulsion of the Thomson River.
   - Another gap in our understanding is the change to aquatic vegetation that may have occurred since European settlement. It is likely that aquatic vegetation communities have changed given the river channel works, access by livestock, and the decline in water quality that has occurred. However, there is no information available with which to quantify such changes.
vi. Connections between the river and its floodplain have been altered, for example by levees. This affects the natural functioning of floodplain and wetland areas. Channel incision in Rainbow Creek has isolated the channel from the floodplain and lowered the local groundwater level.
vii. Biological condition has been altered:
   - *Fish* – The introduction of alien species (e.g. carp) and in-stream barriers to migration have affected fish populations (e.g. reduced abundance and distribution of native species). Migratory species, such as the threatened Australian grayling, cannot pass barriers such as Cowwarr Weir (from Rainbow Creek; and effectiveness of the fishway on the Old Thomson is questionable) and so have been restricted in their range.
   - *Macroinvertebrates* - Information on macroinvertebrate populations collected in recent years suggests that river health in the main channels varied from good to moderate. Further assessment of macroinvertebrate data is required to compare the invertebrate families present with those that would be expected in a lowland river system in good health;
   - *Ecological processes* – little is known about historical changes to processes such as primary and bacterial production, respiration, secondary production and food webs.

Although the total water volume has been reduced significantly, the general pattern of the flow regime in the Thomson River (i.e. high flows in winter-spring, low flows in summer-autumn) remains consistent with the natural pattern. As high flows are unaffected by regulation and low flows have been increased to that recommended by the CRCFE (1999) and Gippel *et al*. (1993), it is the medium sized flow pulses that will be the main focus of future investigations.

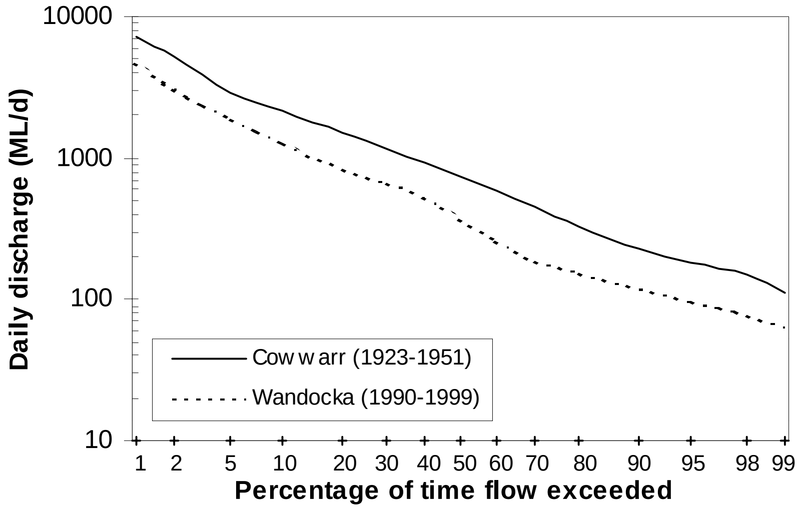



**Figure 5:** **Daily flow duration curves for the lower Thomson River. Note that the flows for Cowwarr are a proxy for natural flows, while flows at Wandocka represent current conditions**

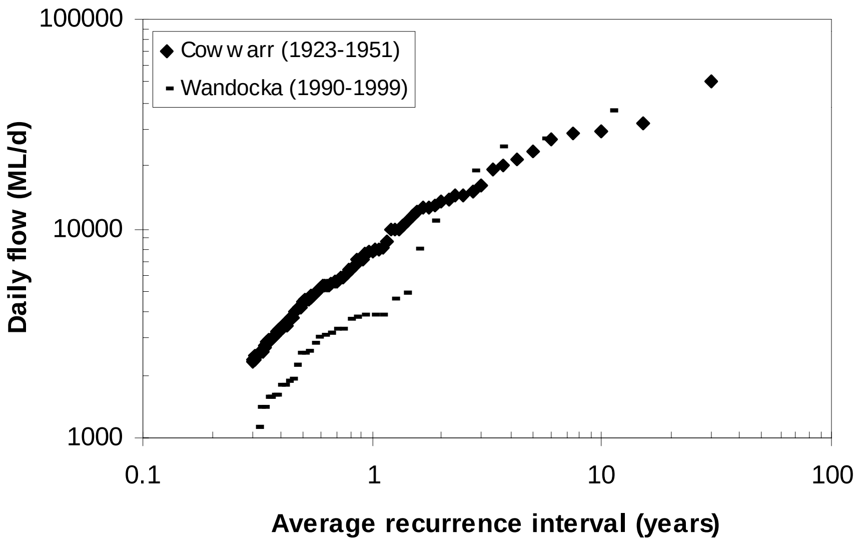
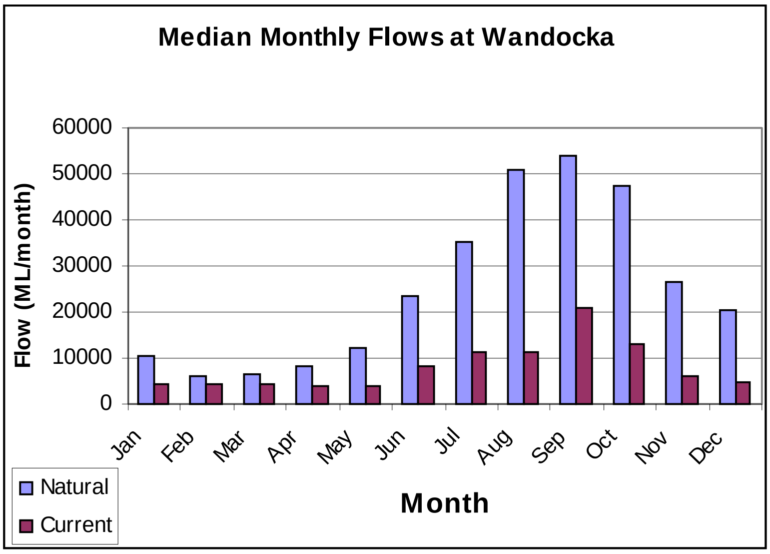
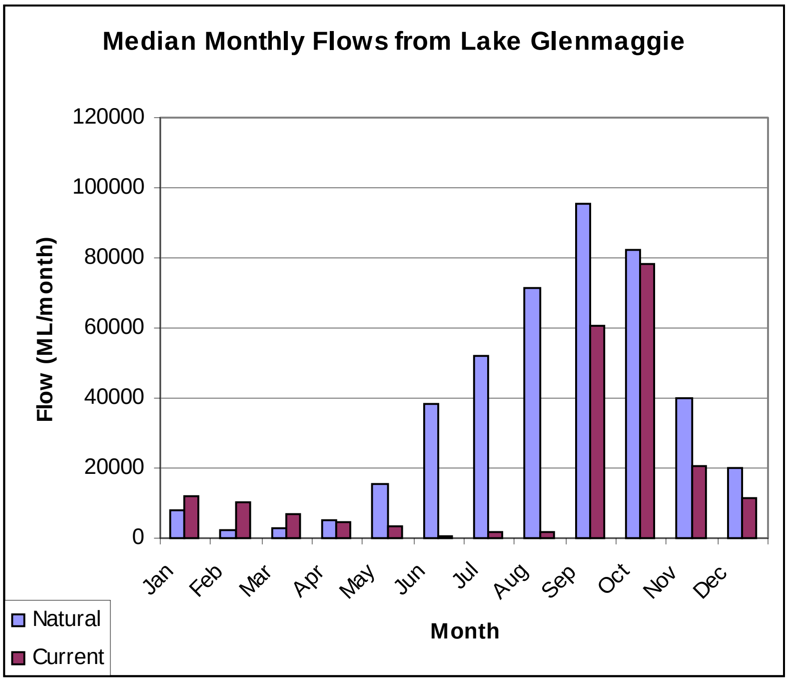



**Figure 6:** **Partial duration flood series for the lower Thomson River. Note that the flows for Cowwarr are a proxy for natural flows, while flows at Wandocka represent current conditions**




(a)




(b)

**Figure 7: Comparison of natural and current median monthly flows in the Thomson River at Wandocka (a) and downstream from Lake Glenmaggie (b)**

### *4.1.2 Macalister River*

Major changes are thought to have occurred in seven main characteristics of the Macalister River system since European settlement:

i. The hydrology of the system has been highly modified, with the flow pattern of the lower Macalister being now reversed in summer and winter; summer flows are higher than would occur naturally and, in winter flows are very low at a time when they would naturally be high (Figure 7a).
ii. Geomorphology has been altered due to direct intervention, removal of riparian vegetation and changed land use and associated activity. This has reduced the diversity of in-stream

habitat for biota (e.g. snags, scour pools) and may have slowed the natural evolution of the channel.

iii. Riparian vegetation has been modified along all reaches by the clearance and grading of land for agriculture (vegetation and wetland areas affected), active snag removal, replanting with willows and access by livestock;

iv. Water quality is poor in the lower reaches, especially for parameters such as phosphorus concentration and turbidity due to the MID and diffuse runoff from agricultural and urban areas. Cold water releases from Lake Glenmaggie may affect river biota such as fish.

v. In-stream habitat has been modified by active snag removal, replanting with willows and access by livestock. As for the Thomson River, changes to aquatic vegetation since European settlement remains a knowledge gap. It is likely that aquatic vegetation communities have changed given the river channel works, access by livestock, and the decline in water quality that has occurred. However, there is no information available with which to quantify such changes.

vi. Connections between the river channels and their floodplains have been altered by levees. This may affect the natural functioning of floodplain and wetland areas.

vii. Biological condition has changed:

- *Fish* – The introduction of alien species (e.g. carp) and in-stream barriers to migration have affected fish populations (e.g. reduced abundance and distribution of native species). Migratory species, such as the threatened Australian grayling, cannot pass barriers such as Maffra Weir and Lake Glenmaggie and so have been restricted in their range. Cold water releases from Lake Glenmaggie will affect fish populations in the Macalister River below the dam. DNRE is currently evaluating cold water releases from dams across Victoria. Preliminary results indicate that the temperature of water released from Lake Glenmaggie is less variable than that recorded at upstream sites (i.e. a smaller temperature range than the water entering the dam), with lower temperatures in summer (particularly when storage levels are high) and warmer temperatures in winter.
- *Macroinvertebrates* - Information on macroinvertebrate populations collected in recent years suggests that river health in the main channels varied from good to moderate. Further assessment of macroinvertebrate data is required to compare the invertebrate families present with those that would be expected in a lowland river system in good health;
- *Ecological processes* – little is known about primary and bacterial production, respiration, secondary production and food webs.

## 4.2 Summary of changes since European settlement

Several of the key issues below may affect the ecology of the river (given that many ecological interactions in the river system are unknown) include:

- Less water or changes to the timing of the flows required to support ecological processes;
- Decreased abundance and distribution of native fish;
- Fewer than expected number of macroinvertebrate families in some river reaches;
- Reduced diversity and abundance of aquatic vegetation;
- A decline in water quality, especially in lower reaches of the river system;
- Changes to natural geomorphological processes that may alter the pace of natural channel evolution and habitat diversity;
- Loss of riparian vegetation diversity, continuity and area; and
- Reduced area, number and quality of wetlands.

## 4.3 Summary of remaining environmental values associated with the river system

The river system still retains many environmental values, even though conditions have been modified since European sttlement. In the study area, environmental values include:

- The pattern of the flow regime in the lower Thomson River, that is similar to natural (although the total volume has been reduced by approximately 50%) and helps to maintain geomorphological, biological and ecological processes;
- Largely natural geomorphological processes that help to maintain physical habitat diversity (e.g. scour pools and undercuts);
- Remnant areas of native riparian and wetland habitat that are pockets of biodiversity in the landscape;
- Connectivity between the river channel and the floodplain that links the rivers and remnant riparian and wetland habitats;
- Generally good quality water flowing from the Aberfeldy and upper Thomson Rivers (although water quality deteriorates downstream in the lower reaches of the study area) that protects beneficial uses, including the maintenance of natural aquatic ecosystems;
- Threatened fish species such as Australian grayling, and other valued fauna such as platypus and freshwater crayfish;
- Areas of the lower Thomson River that have been largely unaffected by previous river management works and are examples of good in-stream habitat (e.g. woody debris or snags).

# 5 VISION AND REHABILITATION OBJECTIVES FOR THE LOWER THOMSON AND MACALISTER RIVERS

The discussion in this chapter focuses predominantly on the Thomson River, as there is more information available for this system. Many of the issues identified for the Thomson are likely to apply to Rainbow Creek and the Macalister River. Issues specific to Rainbow Creek and the Macalister River will be highlighted and should be considered along with the issues identified for the Thomson River, most of which will be common across each river section.

## 5.1 Objective and Target Setting

### *5.1.1 Ecological Objectives*

Feedback from the Advisory Group established for the scoping study has been used to provide a vision for the river system. This vision for the river system can be summarised as:

"P*rovide a healthy ecosystem with diverse habitats (aquatic and terrestrial), communities and species, and an environmental flow regime that will sustain native flora and fauna. The river system will be one that people can access and enjoy, that supports a diverse landscape with multiple uses and values, and is consistent with community values and expectations*".

This vision has both ecological and socio-economic aspects and it is recognised that the two are closely linked. In this report we focus on the ecological objectives and targets, which are:

- The maintenance of in-stream conditions[1] that will support predominantly native flora and fauna;
- Channel evolution that increases physical habitat diversity, especially for Rainbow Creek;
- Riparian vegetation that is dominated by native species, and is continuous along the river and onto the floodplain;
- A river system that has adequate flow connections with the floodplain and associated wetlands;

Landcare Groups in the West Gippsland region have also developed visions for the local environment to help guide their on-ground works. Examples from Landcare groups in the study area are consistent with those described above (Appendix 7). The vision stated above is also consistent with the aims of the various State and local initiatives that seek to improve the environmental condition of catchments and waterways (Appendix 2). The ecological aspects of the vision statement have, therefore, been adopted as objectives to guide future rehabilitation. While the objectives outlined above were developed for the lower Thomson and Macalister Rivers, achieving these objectives will also contribute to the condition of the lower Latrobe River and the Gippsland Lakes.

The socio-economic objective articulated by the Advisory Group was to achieve a catchment that supports agriculture managed in an environmentally sensitive and sustainable manner. Socio-economic considerations will play an important part in the development and implementation of a successful, long-term, rehabilitation plan for the lower Thomson and Macalister rivers, but are not explicitly considered in this Scoping study. Some relevant socio-economic aspects are currently being addressed via other programs (e.g. Gippsland Lakes

[1] This includes ecologically important in-stream components of the river system such as hydrology, fish and macroinvertebrate communities, aquatic macrophytes and water quality

rescue package). Cultural and indigenous issues, while important, have also not been considered in this project.

### *5.1.2 Rehabilitation Targets*

The changes that have occurred in the river system since European settlement can be used to set *directional* targets (rather than *end points*) for rehabilitation. The extensive modification to the river and floodplain system in the study area means that setting pre-European conditions as rehabilitation targets (*end points*) is unrealistic; it is unlikely that the river system could ever be returned to a pristine state. Rehabilitation efforts that focus on achieving a partial return of structure and function lost to disturbance are far more realistic when trying to improve environmental conditions (Lockwood and Pimm 1999).

The major changes thought to have occurred in the river system since European settlement are summarised in Section 4.2. These key issues provide a basis for setting rehabilitation targets.

We recommend that the rehabilitation targets for both the Thomson and Macalister Rivers include:

- Sufficient volume and timing of flows available to support key ecological processes;
- Increased abundance and distribution of native fish;
- An increase in macroinvertebrate diversity in reaches where there are less families than expected;
- Increased diversity and abundance of native aquatic vegetation along the river;
- Improved water quality along the river system;
- Geomorphological processes that are natural and that promote physical habitat diversity;
- Increased diversity, continuity and area of riparian vegetation;
- Increased area, number and quality of wetlands associated with the river system.

Investigations to quantify the above targets will be a critical part of Stage 2 of this project. The activities and investigations associated with each target are considered in the following sections and consolidated in section 5.8.

## 5.2 Flow regimes

Environmental flows will be required to enhance any ecological processes that are found to have been altered by flow regulation. Flow rehabilitation targets should be directly related to their “ecological function” rather than arbitrary hydrological statistics. A number of methods are available for assessing the flows required to maintain river ecosystem, including Downstream Response to Intended Flow Transformations (DRIFT), Cascading Seasonal Flow (CSF) and the Flow Event Method (FEM). All these are still in their early formative stages.

The FEM has been developed by the CRC for Catchment Hydrology as a tool for establishing hydrological targets in regulated systems. It is designed to evaluate the geomorphic and ecological impacts of flow regulation as a basis for planning environmental flow regimes. This method has several advantages for setting hydrological targets for river restoration and is the method proposed for setting environmental flows targets for the Thomson and Macalister rivers (Appendix 4). In particular, the method accounts for the natural dynamics of flow-related processes by using the natural flow regime as a template for an environmental flow regime. A process for using the FEM is proposed in Figure 8.

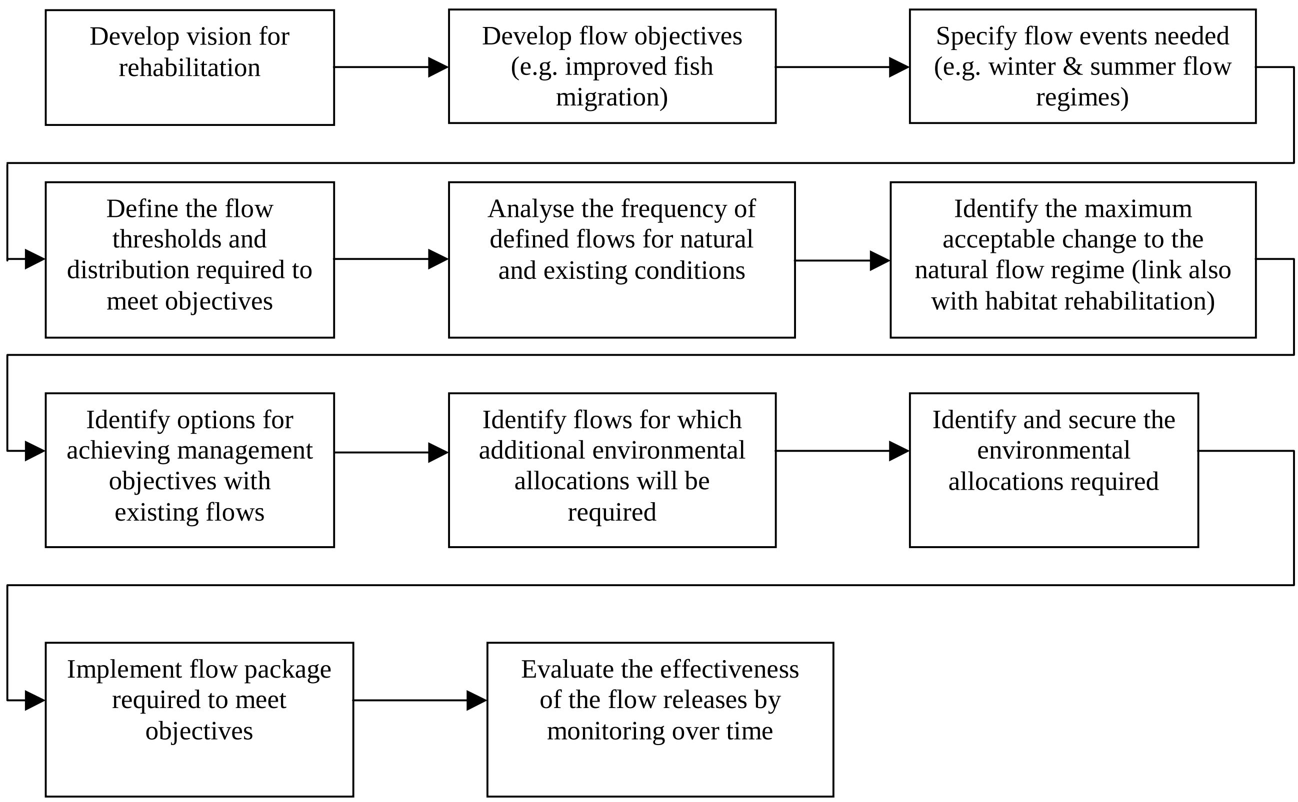



**Figure 8: Quantifying flows required to meet flow-related ecological objectives**

### *5.2.1 Thomson flow targets*

In the Thomson River, a minimum flow regime of 125 ML/d or natural will be delivered in the future, and that large floods have been unaffected by regulation. Therefore, the main emphasis for flow targets should be to examine the ecological effect of the decreased frequency of medium-size flow pulses that has occurred since regulation and diversion of water from the Thomson River.

***What is needed?***

- Modeling of natural versus current flow to provide daily flow data for the lower Thomson river which will allow detailed assessment of environmental flow scenarios;
- Expert panel to use the FEM to define flows required to meet ecological objectives – presumably with emphasis on the medium flow situation
- Evaluate alternative release strategies from Thomson Dam to attain ecological targets set by Expert Panel.

### *5.2.2 Macalister flow targets*

Analysis of hydrological data (cf that already undertaken for the Thomson River) is required to confirm how the flow regime in the Macalister River has changed since regulation and the diversion of water for agricultural and urban supply. Important considerations will be the adequacy of current low-flow releases (e.g. 50 ML/d or natural), which is less than that recommended by the CRCFE (1999), and the ecological effects of a reduced frequency of medium sized flow pulses (assuming the situation is the same as for the Thomson River).

***What is needed?***

- A flow analysis for the Macalister River to identify those components of the flow regime that have been modified by regulation (this work has already been completed for the Thomson River – see Appendix 3);
- Modeling of natural versus current flow to provide daily flow data for the lower Macalister River which will allow detailed assessment of environmental flow scenarios;
- Expert panel to use the FEM to define flows required to meet ecological objectives – presumably with emphasis on the medium flow situation
- Evaluate alternative release strategies from Lake Glenmaggie (including potential for translucent dam releases) to attain ecological targets set by the Expert Panel.

## 5.3 Native fish

To ensure the survival of populations of native fish (i.e. maintaining or improving abundance and diversity) suitable flow, habitat and water quality conditions (including temperature) are required.

Rehabilitation targets for native fish species can be set at a number of levels, for example:

- An increase in the distribution or abundance of a native species in response to the removal or by-pass of in-stream barriers to migration;
- An increase in juvenile fish in response to environmental flows that provide important biological cues such as stimulation of breeding or migration;
- An increased diversity of native species in wetlands that become reconnected to the channel with the removal of levees.

***Flow regimes***

There is a general lack of information available with which to quantify the flows required for the life-cycle of key native fish species, especially those species recognised are threatened (e.g. Australian grayling). This is an area requiring research in the form of long-term studies and has implications for many regulated river systems in Victoria. Basic research such as this will reduce the dependency on expert opinion when quantifying environmental flows in the future. Key species to consider include Australian Grayling (threatened species), Galaxias species (widespread and easily assessed), Tupong and Australian bass (important recreational species). Other non-migratory species such as River blackfish should also be considered.

While the flows necessary to meet for life-cycle requirements of native species are beingdefined, it is recommended that rehabilitation efforts in the short term should focus on improving habitat and water quality conditions. This includes fish passage past in-stream barriers and increasing habitat availability (e.g. via resnagging).

***Barriers***

An important consideration when identifying environmental flows (e.g. when using FEM) to meet the life history requirements (successful breeding and migration) will be the ability of target species to pass barriers to migration, such as weirs and dams. Fish passage will be necessary past Cowwarr Weir, and also past Maffra Weir and Lake Glenmaggie to ensure that native fish species occur across their natural range.

While removing barriers, improving the flow regime and reconnecting wetlands to the main channel will be beneficial to native fish species, such activities may also provide additional habitat for invaders such as carp. However, experience in other river systems suggests that carp and other invading fish species pose less of a problem for native fish species when river health is good (good water quality and abundant habitat) and the flow regime is relatively natural (Gehrke *et al.* 1995; Driver *et al*. 1997; Harris 1997; Hoyt and Robinson 1980, Winston *et al*. 1991). Also, invaders such as carp and Gambusia (mosquito fish) have already been recorded above Cowwarr Weir and above Lake Glenmaggie. Thus, the installation of fish ladders and any future changes to the flow regime are unlikely to promote invaders over native fish species. Implementation of strategies to control alien species such as carp should be considered and alien invaders should also be monitored when the effectiveness of environmental flows is being evaluated.

Gippel *et al*. (1993) and CRCFE (1999) have both recommended the ultimate adoption of Rainbow Creek as the main channel of the Thomson River. However, increasing the relative proportion of flow in Rainbow Creek should only be completed when fish passage along Rainbow Creek and past Cowwarr Weir is available. The management of change in the flow-split between the Old Thomson River and Rainbow Creek will be informed by an investigation of changes to fish migration in response to changed flow in each reach. For example, will fish still travel along the Old Thomson and pass Cowwarr Weir if the flow-split with Rainbow Creek is changed to 60:40, 50:50, 40:60 etc. An optimum flow split will ensure fish passage to the upper reaches of the Thomson and Aberfeldy Rivers and allow increased flow down Rainbow Creek that may improve the geomorphological processes responsible for increased habitat diversity. The Bulk Entitlement Taskforce is currently evaluating the management implications of changes to the flow split between the Old Thomson and Rainbow Creek.

***What is needed?***

- A survey of fish communities across the study area to confirm the extent of the fish population (species and abundance);
- Investigation of aspects of the flow regime important for spawning and migration for coastal native fish species. This will require specific investigations for key native fish species;
- Investigation of species/habitat relationships for native coastal fish species, including the connection of important wetland habitats with the main river channels; and
- Assessment of the efficiency of existing fishway on the ‘Old Thomson’, in addition to providing passage past barriers such as Cowwarr Weir and Maffra Weir;
- Investigation of species/habitat relationships for native coastal fish species;
- Investigation of fish migration response to changes in the flow-split between the Old Thomson and Rainbow Creek;
- Implementation of the National Carp Strategy.

## 5.4 Aquatic vegetation

No published information on the aquatic vegetation of the river system has been found. However, it might be expected that aquatic vegetation, like riparian vegetation, has been extensively modified since European settlement due to factors such as stream bed and bank erosion, river management works, access by livestock and a decline in water quality. While a survey is required to assess the current condition of aquatic vegetation (there is little information with which to judge how aquatic vegetation communities may have changed since European settlement), actions such as the implementation of the Central Gippsland Water Quality Strategy and MID Nutrient Management Plan, and control of livestock access are expected to promote conditions that favour the growth of aquatic plants.

***What is needed?***

- Implementation of the Central Gippsland Water Quality Strategy and the MID Nutrient Management Plan;
- Control of livestock access;
- A survey of aquatic vegetation in the main channels, and a review of their flow and habitat requirements as a prerequisite to establishing rehabilitation targets for aquatic vegetation.

## 5.5 River water quality

A decline in water quality has been noted for parameters such as turbidity and nutrients. A preliminary assessment undertaken by DNRE also indicates that cold water is released from Lake Glenmaggie in summers when storage levels are high.

Flushing flows may be used to improve water quality at times when flow in the rivers cease and pool water quality deteriorates. A decision support system would be helpful to identify conditions conducive to poor water quality in the lower river reaches and opportunities for management such as the provision of flushing flows. However, providing freshes in this way is not a long-term answer to the factors that lead to poor water quality, such as inputs of organic matter, nutrients and suspended solids. The notion that 'dilution is the solution to pollution' is not good management practice. Water quality and nutrient load reduction targets for the MID and the Thomson and Macalister rivers have been set by the Latrobe SEPP and are being pursued via other water quality management plans (e.g. Central Gippsland Water Quality Strategy, MID Nutrient Management Plan, Lake Wellington Salinity Management Plan). The use of environmental flows to address water quality issues is not recommended.

Cold water releases from large dams are known to affect the biology of biota such as native fish**.** The distance from the Thomson Dam to Cowwarr Weir and the inflows of water from the Aberfeldy River means that cold water pollution is unlikely to be a problem in the Thomson River. Cold water releases from Lake Glenmaggie have been noted (T. Ryan, pers. comm.) and their extent is currently being quantified by DNRE.

***What is needed?***

- Continued implementation of the Central Gippsland Water Quality Strategy, the MID Nutrient Management Plan and the Lake Wellington Salinity Management Plan;
- Quantification of the extent of cold water releases from Lake Glenmaggie and an assessment of options to avoid cold water releases (e.g. Sherman 2000) to ensure that the benefits of environmental flow releases are not compromised.

## 5.6 Channel evolution and physical habitat diversity

A balanced environmental flow regime should contain flows that periodically remove fine sediments from the bed surface, minimise the encroachment of vegetation into the channel, and result in a diversity of small-scale river bedforms (Stewardson and Gippel 1997). Flow events serve to maintain river channel morphology (and therefore in-stream habitat) by mobilising bed and bank sediments. The build up of fine sediment can degrade in-stream habitat quality, and channel contraction can cause loss of habitat area. The build up of sediment in a stream may possibly lead to catastrophic channel change when a large flood overtops an impoundment. Such channel-forming processes are not well understood and can vary regionally or throughout a river basin.

The history of channel clearing in the Thomson and Macalister Rivers means that in-stream physical habitat diversity is lacking in many areas. Some of this habitat may be replaced by reintroducing woody debris to the rivers. This begs the question of how much woody debris should be returned, and where? A section of the lower Thomson River has already been identified as a 'template' for snag density (Gippel *et al.* 1996) that can be applied to prioritise areas for reintroducing woody debris, a resource that is likely to be in short supply.

The impact of willow invasion on river geomorphology is now well understood and the WGCMA has an established willow control program that is part of its native vegetation plan.

***What is needed?***

- Investigations of geomorphological processes and their role in providing physical habitat diversity. Investigations should include:
  - The continued deepening of Rainbow Creek;
  - Changes to sediment movement (if any) due to the presence of the dams and its impact on habitat quality;
  - The effect of desnagging (where undertaken) on physical habitat diversity.
- Development of relationships between changes to channel shape and habitat diversity to support key river biota;
- Continued implementation of the WGCMA Native Vegetation Plan.

## 5.7 Riparian and wetland areas

The limited information available (Appendix 3) suggests that the riparian zone along the Thomson and Macalister Rivers has been extensively modified since European settlement. In many instances, the riparian zone has been reduced to a thin line of trees or shrubs with an understorey of grass, significantly different to the extensive riparian and wetland system represented on maps of the 1850's (Jones 1985). Land clearance and levelling, livestock access, stream bank erosion and isolation from the river channel (e.g. due to the presence of levees or channel incision in Rainbow Creek) are some of the factors likely to have contributed to the decline in riparian and wetland areas.

Riparian areas are important for maintaining stream health and biodiversity (Gregory *et al*. 1991, Naiman and Decamps 1997), because they:

- Harbour distinctive flora and fauna;
- Supply organic material and timber (woody debris) to streams;
- Supply fauna such as macroinvertebrates to streams;
- Serve as wildlife corridors;
- Process and transform the nutrients transferred from terrestrial systems before they enter waterbodies;
- Provide shade for the stream and in-stream habitat.

Riparian and wetland areas are usually very productive and diverse ecosystems (Boon *et al.* 1990, Hillman 1986). These areas are bound to the river flow pattern and affected by changes in its frequency, duration, and seasonal pattern; they depend on high river flows for their water supply and their pattern of inundation is dependent on characteristics of the flow regime and the river height at which they are joined to the channel. The biota that reside in these systems have evolved to cope with both wet and dry conditions.

***What is needed?***

- A survey to identify high priority (i.e. largely natural) riparian areas and remnant wetlands and their condition, including flood levels and the flows required for wetting;
- Identification of the crucial flows required to sustain keystone riparian and wetland vegetation communities or species (e.g. river redgum);
- A survey of levees and identification of those that should be removed to ensure overbank flows reach key wetlands.
- Identification of options for providing crucial flows, if required (e.g. piggy back on Aberfeldy flows in the Thomson River);

The WGCMA is already implementing its Native Vegetation Plan, which includes willow removal, replanting the riparian zone with native species, and the exclusion of livestock to protect waterways and riparian vegetation. The implementation of this plan should continue, but should be reviewed to explore priority areas for revegetation in light of investigations that identify priority areas for protection.

A section of the lower Thomson River below Bundalaguah contains relatively intact riparian and wetland vegetation, as previous river management works undertaken along other river sections did not extend to this area (R. Scott, pers. comm.). This section of the Thomson should be surveyed (e.g. type and position of in-stream habitat features; riparian vegetation communities, wetland communities) so it can be used as a ‘reference site’ (if required) against which to gauge relative riparian and wetland condition and to set targets for rehabilitation.

## 5.8 Summary of issues and actions

The issues and actions described in the previous sections are summarised into the following tables (Tables 1-6). Most of the issues in Tables 1-4 are common to the Thomson River, Rainbow Creek and the Macalister River. Issues or activities that are specific for Rainbow Creek and the Macalister River are identified in Tables 5 and 6. Issues or activities that are flow-related are shaded. The indicative costs and likely timeframes associated with the investigations listed in the Tables 1-6 are outlined in Appendix 8.

Actions for remediation identified in the tables generally relate to existing environmental management programs, including the riparian revegetation works of the WGCMA and local Landcare Groups, the flow trials being undertaken by the Flows Working Group and catchment management and nutrient management plans designed for the MID. These works will form a significant part of an overall rehabilitation plan and should continue apace while the plan is developed and finalised.

Many of the high priorities are related to ecological processes. Ecological knowledge is very limited at present, but is essential if the river system is to be managed in a sustainable manner. Priority for action should first go to flow-related issues, followed by investigations related to in-stream habitat, and then those related to floodplain and wetland issues.

**Table 1: Actions to achieve or maintain an in-stream environment that supports native flora and fauna. Issues that are flow-related are shaded.**

| Objective | Target | Source of Degradation | State of Knowledge | On-ground Actions | Priority for Action | Investigations Required | Investigation Priority |
|---|---|---|---|---|---|---|---|
| **The maintenance of an in-stream environment that will support predominantly native flora and fauna, including:** | | | | | | | |
| • **Hydrology** | • Sufficient volume and timing of flows available to support key ecological processes | • River regulation and diversion of water for agricultural and urban supply | • Poor | - | - | • Model natural versus current daily flow to allow detailed assessment of future environmental flow scenarios<br>• Use the FEM as a tool for defining future environmental flows<br>• Evaluate alternative release strategies from Thomson Dam to attain ecological targets | • High<br>• Medium<br>• Medium |
| • **Native Fish** | • Increased native fish abundance and distribution longitudinally down the river | • Loss of spawning and migration cues | • Poor | - | - | • Conduct a survey to confirm the extent of degradation and to quantify rehabilitation targets<br>• Investigate aspects of the flow regime important for the spawning and migration for coastal native fish species | • High<br>• High |
| | | • Lack of effective fish passage | • Good | • Design and install an appropriate fishway on Cowwarr Weir | • High | • Check efficiency of existing fishway on the Old Thomson | • High |
| | | • Loss of physical habitat | • Medium | • Reintroduce structural habitat (e.g. snags) based on information from the lower Thomson River | • High | - | - |
| | | • Impacts associated | • Medium | • Implement the National | • Medium | - | - |

| Objective | Target | Source of Degradation | State of Knowledge | On-ground Actions | Priority for Action | Investigations Required | Investigation Priority |
|---|---|---|---|---|---|---|---|
| | | with alien species such as carp | | Carp Strategy | | | |
| | | • Loss of hydraulic habitat through reduction of flows > 125 ML/d | • Poor | - | - | • Investigate species/habitat relationships for native fish species | • High |
| | | • Loss of wetland connectivity | • See wetland objectives | | | | |
| • **Macroinvertebrates** | • Increase the observed number of families | • Reduced habitat availability | • Poor | - | - | • Reanalyse existing data sets to assess invertebrate status | • Low |
| | | • Poor water quality | • Medium | • Implement the Central Gippsland WQ Strategy<br>• Implement the MID Nutrient Management Plan | - | • Reanalyse existing data sets to assess invertebrate status and quantify rehabilitation targets | • Low |
| • **Aquatic Vegetation** | • Increase the diversity and abundance of native aquatic vegetation along the river | • Poor water quality | • Poor | • Implement the Central Gippsland WQ Strategy<br>• Implement the MID Nutrient Management Plan | • Medium | • Survey aquatic vegetation in the main channels and review their flow and habitat requirements. Use survey information to quantify targets for rehabilitation | • Medium |
| | | • Erosion | • Good | • Control bed and bank erosion | • Medium | - | - |
| | | • Livestock access | • Good | • Control livestock access to waterways | • High | - | - |
| • **Water Quality** | • Improve water quality along the river system, especially suspended solids and nutrients | • Agricultural land management | • Medium | • Implement the Central Gippsland WQ Strategy | • Medium | - | - |
| | | • Agricultural and urban runoff | | • Implement the MID Nutrient Management Plan | • Medium | - | - |
| | | • Stream erosion | • Good | • Control bed and bank erosion | • Medium | - | - |
| | | • Livestock access | • Good | • Control livestock access | • Medium | - | - |

**Table 2: Actions to promote natural geomorphological processes. Issues that are flow-related are shaded.**

| Objective | Target | Source of Degradation | State of Knowledge | On-ground actions | Priority for Action | Investigations Required | Investigation Priority |
|---|---|---|---|---|---|---|---|
| **Geomorphological processes and channel evolution that increase or maintain physical habitat diversity** | • Largely natural geomorphological processes and increased physical habitat diversity | • Lower annual flow volume and loss of medium sized pulses | • Poor | - | - | • Investigate the interaction between flow and the size and shape of the river channel<br>• Relate changes to channel shape and habitat diversity to river biota | • High<br>• Medium |
| | | • Willow invasion | • Good | • Continue WGCMA Native Vegetation Plan | • High | - | - |

**Table 3: Actions to meet objectives for native riparian vegetation**

| Objective | Target | Source of Degradation | State of Knowledge | On-ground actions | Priority for Action | Investigations Required | Investigation Priority |
|---|---|---|---|---|---|---|---|
| **Riparian vegetation that is dominated by native species, and continuous along the river and into the floodplain** | • Increased native vegetation diversity, continuity and area | • Previous floodplain and river management (land clearance and river management works) | • Medium | • Cease land clearing<br>• Revegetate degraded riparian areas with native species (i.e. continue WGCMA Native Vegetation Plan) | • High | See Table 4 | - |
| | | • Reduced frequency of bankfull and annual (natural) flows | • Poor | - | - | • Identify the crucial flows required to sustain keystone riparian vegetation communities or species (e.g. river redgum)<br>• Identify options for providing crucial flows if required (e.g. piggy back on Aberfeldy flows in the Thomson River) | • High<br>• High |
| | | • Livestock access | • Medium | • Fence off riparian vegetation | • High | - | - |
| | | • Bank erosion | • Medium | • Control sources of erosion | • High | - | - |
| | | • Weed invasion | • Medium | • Control weeds (including willows) and with native species | • High | - | - |

**Table 4: Actions to achieve wetland objectives. Issues that are flow-related are shaded.**

| Objective | Target | Source of Degradation | State of Knowledge | Actions for Remediation | Priority for Action | Investigations Required | Investigation Priority |
|---|---|---|---|---|---|---|---|
| **Ensure adequate flow connections between wetlands and the river system** | • Increased area, number and quality of wetland habitats<br>• Largely natural wetting and drying cycle | • Isolation from river (lack of flow) | • Poor | - | - | • Survey to identify remnant wetlands and their condition, identify flood levels and flows required for wetting and drying. Use collected information to quantify rehabilitation targets. | • High |
| | | • Land clearance | • Medium | • Cease land clearing | • High | - | - |
| | | • Livestock access | • Good | • Fence off wetlands | • High | - | - |
| | | • Levees | • Medium | - | - | • Identify levees and those that can be modified to ensure overbank flows reach key wetlands | • High |

**Table 5: Actions specific to Rainbow Creek**

| Objective | Target | Source of Degradation | State of Knowledge | Actions for Remediation | Priority for Action | Investigations Required | Investigation Priority |
|---|---|---|---|---|---|---|---|
| **The maintenance of an in-stream environment that will support predominantly native flora and fauna, including:** | • Increased native fish abundance and distribution | • Lack of effective fish passage at Cowwarr Weir | • Good | • Design and install appropriate fishway on Cowwarr Weir | • High | - | - |
| | | • Loss of spawning and migration cues | • Poor | - | - | • Undertake flow split trials to gauge the response of native fish to changes in flow between Rainbow Creek and the Old Thomson | • High |
| **Geomorphological processes and channel evolution that increases physical habitat diversity** | • Largely natural geomorphological processes and increased physical habitat diversity | • Continuing evolution of Rainbow Creek | • Poor | - | - | • See Table 2 | |

**Table 6: Actions specific to the Macalister River**

| Objective | Target | Source of Degradation | State of Knowledge | On-ground actions | Priority for Action | Investigations Required | Investigation Priority |
|---|---|---|---|---|---|---|---|
| **The maintenance of an in-stream environment that will support predominantly native flora and fauna, including:** | • Increased native fish abundance and distribution | • Lack of effective fish passage<br>• Cold water releases from Lake Glenmaggie | • Medium<br>• Poor | • Design and install an appropriate fishway on Maffra Weir<br>• Design and install an appropriate fishway on Lake Glenmaggie<br>- | • High<br>• Low<br>- | -<br>-<br>• Investigate the extent of cold water releases from Lake Glenmaggie | -<br>-<br>• High |
| | • Less water available to support key ecological processes | • River regulation<br>• Diversion of water for agricultural and urban supply | • Poor | - | - | • Undertake analysis of existing flow data to confirm changes to river hydrology since regulation<br>• Model natural versus current daily flow to allow assessment of environmental flow scenarios<br>• Evaluate translucent dam releases from Lake Glenmaggie using FEM | • High<br>• Medium<br>• High |

# 6 PERFORMANCE EVALUATION (MONITORING)

It is essential that a robust monitoring and evaluation program be put in place to measure the major changes taking place and to assist the river managers to assess whether their on-ground rehabilitation actions will result in the stated targets being achieved. Some targets may be achieved relatively quickly (e.g. 1 to 2 years), while others may only be achieved after a considerable period (e.g. decades). Monitoring must also be sufficient to detect changes that occur at different spatial scales or to discern subtle effects within naturally variable systems.

We recommend that a monitoring program be established for both the Thomson and Macalister rivers. The program implemented should have the sensitivity to indicate whether the system is improving or not; it is unlikely that any monitoring program will be able to detect changes resulting from any individual on-ground action (which may be difficult in any event due to confounding factors associated with ongoing catchment activities). This approach will be strengthened by the collection of 'before' data in addition to data collected after rehabilitation actions have commenced.

Further details on the type of monitoring program that needs to be established are provided in Appendix 6. The monitoring program will include:

- An outline of experimental design;
- Flow monitoring to ensure environmental flows are delivered;
- Fish species and abundance, size and age distribution and migration;
- Riparian and wetland vegetation community structure;
- In-stream habitat mapping;
- Aerial photography and surveys to assess long term changes in river geomorphology;
- Biological and physico-chemical water quality.

These measures should be revised following additional investigations that will form part of stage 2 (investigative works) of this study.

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## APPENDIX 1 DEGRADED RIVER SYSTEMS

The processes that lead to degraded river systems may occur over time frames ranging from days (e.g. discharge of pollutants) to years (e.g. land degradation; salinity effects). In cases where degrading processes are widespread and persistent, it is highly likely that the effect of rehabilitation efforts will take many years to become apparent. It is also possible that river condition will continue to decline for some time, even after rehabilitation works have been started (Figure 9).

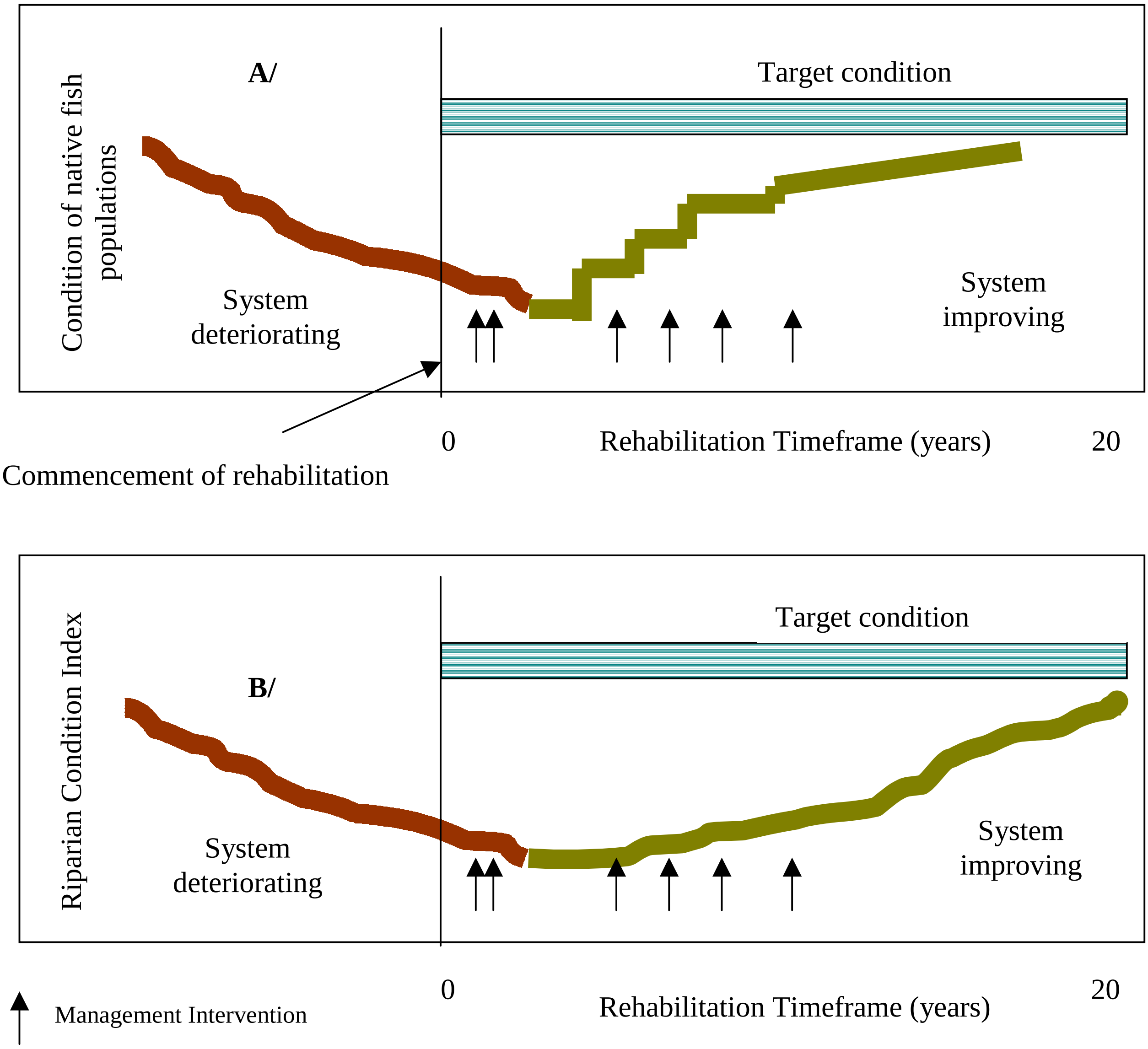



**Figure 9: Possible degradation and recovery in response to rehabilitation efforts for native fish (A) and the riparian zone (B). Note: recovery is compared with a reference condition representing some desired state. Target and rehabilitation site conditions are represented by bands, recognising that conditions will vary naturally within each band.**

Adopting rehabilitation targets of ‘pristine condition’ serve to provide the direction but not end points of rehabilitation; in heavily modified systems such as the Thomson and Macalister Rivers, it is unrealistic to expect a return to pristine conditions. There may also be differences between previousy occurrences and the characteristics that people want now (e.g. trout may be favoured by some sections of the community). Some of the key questions for this project are:

- How has the river system changed?
- How would we like it to be?
- How can we assess the performance of rehabilitation efforts?

The ecosystem responses shown in Figure 9 provide one perspective on river condition. They allow us to consider factors such as appropriate time scales, rehabilitation targets (usually against reference conditions) and adaptive management actions. They also enable us to ask questions such as:

- What is included in assessments of ‘river condition’?
- How do we measure it?
- Has it changed for the worse?
- Can we distinguish trends from natural variability?
- How do we set priorities?

## APPENDIX 2 SYNOPSIS OF RELEVANT RESOURCE MANAGEMENT PROGRAMS

**State Environment Protection Policy (Waters of Victoria)**

Broad statewide water quality objectives have been set via the SEPP (Waters of Victoria) and refined in - Schedule F5: Waters of the Latrobe and Thomson River Basins and Merriman Creek Catchment, to specifically address water issues in those catchments (Government of Victoria 1988; State of Victoria 1996). Schedule F5 was developed with extensive community consultation and ownership of objectives and beneficial uses. The SEPP tries to achieve a balance between environmental, economic and social needs. The most sensitive beneficial use, the maintenance of natural aquatic ecosystems and associated wildlife, is the basis for many of the objectives.

The Latrobe SEPP is divided up into various segments that reflect similar landuse and environmental potential, and therefore the same needs for protection or management. In each segment beneficial uses are identified and objectives developed to protect those uses. Thomson River and its tributaries down stream of Cowwarr Weir to its confluence with the Latrobe River, and the Macalister River below Lake Glenmaggie are recognised as one segment, Segment D This segment is recognised as having predominately agricultural activities, other segments have reserves and conservation areas, wetlands, forestry, industrial areas, and irrigation drainage and have different beneficial uses and objectives. Segment B (Thomson River and its tributaries upstream of Cowwarr Weir) may also be considered, for example to assess fish migration above and below Cowwarr Weir or the release of water from Thomson Dam. Segment F may be considered in terms of connection of the Thomson and Macalister Rivers with the floodplain and as a potential source of poor water quality discharging into the rivers. Beneficial uses to be protected for these segments are listed in Table 7, while water quality indicators and variation from acceptable levels are listed in Tables 8 and 9. Relevant aspects of the attainment program include the preparation of a water quality management strategy, aspects of stream management, the review or development of management plans related to land, drainage or waterways, the management of point-sources of pollution and a nutrient reduction strategy for the Macalister Irrigation District.

**Table 7: Beneficial uses in the Schedule Area**

| Beneficial Use | Segment B | Segment D | Segment F |
|---|---|---|---|
| **Maintenance of Aquatic Ecosystems and Associated Wildlife** | | | |
| Natural ecosystems with occasional disturbance due to human activity | ✓ | | |
| Modified ecosystems | | ✓ | |
| Highly modified ecosystems with some habitat values | | | ✓ |
| **Potable Water Supply** | | | |
| With treatment (disinfection only) | ✓ | | |
| With treatment (disinfection & removal of suspended solids) | | ✓ | |
| **Recreation** | | | |
| Primary contact (e.g. swimming, water skiing) | ✓ | ✓ | |
| Secondary contact (e.g. boating, fishing) | ✓ | ✓ | |
| Aesthetic enjoyment (e.g. walking by the waters) | ✓ | ✓ | ✓ |
| **Agricultural Water Supply** | | | |
| Stock watering | | | ✓ |
| Irrigation | | | |
| **Fishing and Aquaculture** | ✓ | ✓ | ✓ |
| **Industrial Water Use** | ✓ | ✓ | ✓ |
| **Aquifer Recharge** | ✓ | ✓ | ✓ |

**Table 8: In-stream water quality indicators and objectives**

| Indicators (units) | | Segment B | Segment D | Segment F |
|---|---|---|---|---|
| pH (pH units) | Acceptable range | 5.5-8.0 | 6.0-8.5 | 6.0-8.5 |
| Dissolved Oxygen (mg/L & % saturation) | Min. concentration | >8.0 | >6.0 | >5.0 |
| | Min. saturation | >85% | >65% | >55% |
| Toxicants (formula) | Maximum | <0.2T | <T | <T |
| Salinity (mg/L) | Ann. 90th percentile | <200 | <400 | <700 |
| | Maximum | <300 | <500 | <1,000 except Newry Creek and Nuntin Creek where <1,200 shall apply |
| Suspended Solids (mg/L) | Ann. 50th percentile | <5 | <20 | <60 |
| | Ann. 90th percentile | <10 | <40 | <100 |
| Turbidity (NTU) | Ann. 50th percentile | <5 | <15 | <30 |
| | Ann. 90th percentile | <10 | <30 | <60 |
| Colour (Pt.Co. units) | Ann. 50th percentile | N* | <60 | <100 |
| | Ann. 90th percentile | N* | <100 | <150 |
| Total Phosphorus (mg/L) | Ann. 50th percentile | <0.015 | <0.040 | <0.070 |
| | Ann. 90th percentile | <0.030 | <0.065 | <0.120 |
| Total Nitrogen (mg/L) | Ann. 50th percentile | <0.60 | <0.80 | <1.00 |
| | Ann. 90th percentile | <1.00 | <1.40 | <1.80 |
| E. coli (organisms/100mL) | 42 day geometric mean | N* | <200 | <1000 |
| Temperature (degrees Celsius) | | See Table 3 | See Table 3 | See Table 3 |

N* No variation from background levels

**Table 9: Acceptable variation from background levels**

| Indicators (units) | | Segment B | Segment D | Segment F |
|---|---|---|---|---|
| Temperature (degrees Celsius) | Ann. 90th percentile | <0.3 | <1.5 | <1.5 |
| | Maximum | <0.5 | <2.0 | <2.0 |
| | Rate of change | <1.0 in 30 minutes | <1.0 in 30 minutes | <1.0 in 30 minutes |
| pH (pH units) | Variation from N | <0.5 | <1.0 | <1.0 |
| Salinity | (% increase) | <5% | <10% | - |
| Turbidity (NTU) | (% increase) | <5% | - | - |
| Suspended Solids (mg/L) | (% increase) | <5% | - | - |
| Colour (Pt.Co. units) | (% increase) | - | <20% | <50% |

**Victorian River Health Strategy**

DNRE and the Victorian Catchment Management Council are currently developing the Victorian River Health Strategy (VRHS) that will provide a management framework to bring together relevant legislative initiatives and obligations to achieve healthy rivers. The implementation of the VRHS will ensure that our waterways are sustainable in that that they will continue to support the species, communities and ecological processes which are needed to ensure the survival of healthy rivers into the future. There are three major aspects of river health that should be considered in any management decision relating to rivers. These are:

- Maintaining the longitudinal, lateral and vertical linkages between the river and aspects of its catchment;
- Maintaining a range of habitats and biota;
- Maintaining ecological processes.

The Council has defined what constitutes a healthy waterway to help establish its objectives. An ecologically healthy river will have flow regimes, water quality and channel characteristics such that:

- In the river and riparian zone, the majority of plant and animal species are native and no exotic species dominates the system;
- Natural ecosystem processes are maintained;
- Major natural habitat features are represented and are maintained over time;
- Native riparian vegetation communities exist sustainably for the majority of its length;
- Native fish and other fauna can move and migrate up and down the river;
- Linkages between river and floodplain and associated wetlands are able to maintain ecological processes;
- Natural linkages with the sea or terminal lakes are maintained;
- Associated estuaries and terminal lake systems are productive ecosystems.

**West Gippsland Regional Catchment Strategy**
The vision adopted for the West Gippsland Regional Catchment Strategy, developed in consultation with the community, is:

'To achieve a sustainable balance between the human need to utilise the natural resources of the region and the responsibility to ensure that these natural resources remain available for future generations'.

The Strategy also recognised the various State Government Acts related to resource management in the region:

- Forests Act 1958
- Fisheries Act 1995
- Environment protection Act 1970
- Land Conservation Act 1970
- National Parks Act 1975
- Wildlife Act 1975
- Crown Land (reserves) Act 1978
- Heritage Rivers Act 1982
- Conservation Forests and Land Act 1987
- Planning and Environment Act 1987
- Flora and Fauna Guarantee Act 1988
- Local Government Act 1989
- Water Act 1989
- Mineral resources Development Act 1990
- Catchment and Land Protection Act 1994
- Extractive Industries Development Act 1995

Each of the five programs developed to address regional priorities (water quality, pest, salinity, habitat and biodiversity, land) has relevance to this project. While the programs identify broad objectives and actions, there are no specific targets that may be adopted for river rehabilitation.

*Water Program*
The objectives of the water program is 'to protect and improve the water quality in streams and receiving waters i.e. lakes, reservoirs, wetlands and coastal waters.' Key aspects will include:

- The management of the water supply catchments to protect water quality;
- The management of waterways to maintain or restore riparian and aquatic habitat, stream bed and banks, flow regimes and the drainage function of streams;
- Flow management to balance the competing demands on water and to protect water systems, water quality and aquatic systems;

To achieve its objectives, the water program aims to meet SEPP requirements, reduce the probability of algal blooms by reducing the nutrient loads entering waterbodies, protect and sustain aquatic life, enhance the aesthetic value of water systems, reduce the levels of water-borne pathogens, minimise the unnatural fluctuation of in-stream temperatures and develop an effective monitoring process.

*Pest plants and animals and fish program*
The pest program aims to reduce the impact of pests on flora, fauna and primary productivity by reducing infestations of established pests, preventing the introduction or establishment of pest in areas where they pose potential threats, and by coordinating effective and environmentally sound methods of control. The issues to be addressed by this program includes:

- Loss of production;
- Fauna predation;
- Flora degradation;
- Aquatic habitat/species;
- Tourism/recreation; and
- Social harmony

*Habitat Program*
The habitat program aims to provide:

- Protection and enhancement:
  - ➢ The habitat program aims retain the indigenous genetic biodiversity,
  - ➢ Protect habitat and connections, and
  - ➢ maintain and improve ecosystem balance.

- Parks, reserves and wetlands:
  - ➢ To protect flora and fauna;
  - ➢ Retain the indigenous genetic diversity;
  - ➢ Balance tourism and recreation use with ecosystem maintenance.

- Re-establishment and corridors:
  - ➢ To restore threatened species to sustainable levels;
  - ➢ Recreate integrated habitat corridors; improve ecosystem balance.

Specific actions such as the mapping of ecological vegetation classes were identified; it is not clear whether such work has been completed or is available for this project.

*Salinity Program*
The salinity program aims to ‘implement actions needed for the sustainable use of land and water which will reverse the trend of rising water tables and increasing salinity’. Specific actions aim to:

- Protect irrigation and dryland agriculture;
- Preserve the conservation values of waterways, lakes and wetlands;
- Prevent damage to infrastructure; and develop community awareness programs.

*Land Program*
The land program seeks to encourage the sustainable use of land, and to minimise and improve soil resources. Actions identified to prevent erosion, maintain and improve soil structure are also likely to have spin-offs for aquatic ecosystems.

**MID Nutrient Management Plan**
The MID nutrient management plan is being prepared to help meet the SEPP target of a 40% reduction in phosphorus loads entering Lake Wellington from irrigation drains by 2005. The 40% reduction target was considered by the Latrobe SEPP (EPA 1996) to be the level of improvement that can be achieved through the adoption of commonly available measures for phosphorus reduction.

**Environmental Flows Package**
An environmental flow package for the Thomson and Macalister Rivers has been developed for inclusion in the bulk entitlements for Melbourne Water and Southern Rural Water. The package was developed by West Gippsland CMA, Southern Rural Water, Melbourne Water, the Gippsland Coastal Board and DNRE and in the form of an Agreement between these agencies. The bulk entitlement for the Thomson and Macalister Rivers was negotiated while this scoping study was being compiled and will be reviewed in three years time.

The environmental flows for the lower Thomson and Macalister rivers are presented below. Additional works were recommended to:

- Undertake a flow trial to identify system losses or gains;
- Refine future environmental flow objectives;
- Develop a riparian vegetation improvement program;
- Investigate dam ‘translucency’ rules for Lake Glenmaggie;
- Develop protocols for allocating water efficiency savings; and
- Review opportunities to enhance flood flow patterns.

*Environmental Flow for the Macalister River*

(a) Southern Rural Water must provide a minimum flow in the Macalister River below Maffra Weir of 60 ML/day, except as provided for in paragraphs (b) to (d).

(b) The passing flow can be reduced to 30 ML/day if:
  - for any month between June and October (inclusive), the inflow to Lake Glenmaggie for the previous month is less than the 80th percentile inflow to Lake Glenmaggie for that previous month; and
  - for November, the volume in Lake Glenmaggie during November is less than 133 000 ML.

(c) If the passing flow has been reduced to 30 ML/day under paragraph (b) in any year, it is to be maintained until the end of May in that year unless:
  - for any month between June and October (inclusive), the inflow to Lake Glenmaggie for the previous month exceeds the 80th percentile inflow to Lake Glenmaggie for that previous month; or
  - for the months of August to January (inclusive), the volume in Lake Glenmaggie exceeds 185 000 ML;

  in which case, the passing flow is to be restored to 60 ML/day.

(d) If the inflow to Lake Glenmaggie on any day as calculated by Southern Rural Water is less than the passing flow calculated under paragraphs (b) and (c), the passing flow may be reduced to the same value as the inflow to Lake Glenmaggie.

(e) For the purposes of paragraph (d), the inflow to Lake Glenmaggie is to be estimated using the method described in the September 1995 report by Sinclair Knight Merz, ‘Thomson Macalister Natural Flow Indicators’.

(f) For the purposes of paragraphs (b) and (c), the 80th percentile of inflow to Lake Glenmaggie is specified in the following table. The values in the table were calculated from recorded and estimated monthly inflows to Lake Glenmaggie from July 1955 to

March 2000. Southern Rural Water must re-calculate these values every three years, using up-to-date recorded inflows to Lake Glenmaggie.

| Month | 80th percentile flow ML/month |
|---|---|
| May | 5,050 |
| June | 15,950 |
| July | 26,650 |
| August | 45,000 |
| September | 58,350 |
| October | 43,800 |

(g) Southern Rural Water must ensure that the passing flow determined under paragraphs (a) to (f) is passed through the lower reaches of the Macalister and Thomson rivers and is not taken by licensed diverters.

(h) The passing flow is to be based on the average daily flow at Maffra Weir (Note: this is consistent with SRW's normal operating practice of making regulations based on measurements] made once each day, but flows are measured by continuous recorder).

(i) Southern Rural Water must provide the passing flows specified in paragraphs (a) to (f), $Q_M$ , within the following operating tolerances:
- the average flow on any day is not to be less than 50% of $Q_M$ at all times;
- the average flow on any day is not to be less than 70% of $Q_M$ on more than 7 days within any continuous 28 day period; and
- the average flow on any day is not to be less than $Q_M$ on more than 14 days within any continuous 28-day period.

*Environmental Flow for the Thomson River and Rainbow Creek below Cowwarr Weir*

(a) Subject to the flow monitoring trial proposed in Item 5, Southern Rural Water must provide a minimum instantaneous environmental flow in the Thomson River and Rainbow Creek between Cowwarr Weir and Wandocka of:
- the lesser of 125 ML/day, and the natural flow; or
- if the natural flow is less than 50 ML/day, 50 ML/day.

(b) The natural flow is to be estimated using the method described in the September 1995 report by Sinclair Knight Merz, 'Thomson Macalister Natural Flow Indicators'.

(c) Southern Rural Water may supply licensed diverters below Cowwarr Weir only from water available to it above Cowwarr Weir, from the Thomson siphon, and gains to the river below Cowwarr Weir.

(d) Compliance is to be based on average daily flow at Cowwarr Weir and Wandocka Gauging Station (Note: This is consistent with SRW's normal operating practice of making regulations based on measurements made once each day, but flows are measured by continuous recorder).

(e) Southern Rural water must provide the passing flow specified in paragraph (a), $Q_W$ , within the following operating tolerances:
- the average flow on any day is not to be less than 65% of $Q_W$ at all times;
- the average flow on any day is not to be less than 80% of $Q_W$ on more than 7 days within any continuous 28 day period; and
- the average flow on any day is not to be less than $Q_W$ on more than 14 days within any continuous 28-day period.

Operating rules for the distribution of flow between the old course of the Thomson River and the Rainbow Creek are to be developed jointly by West Gippsland CMA and Southern Rural Water for inclusion in Southern Rural Water's environmental obligations under clause 16 of its bulk entitlement. The operating rules are to include -

- sharing of the environmental flow one third to the old course of the Thomson River and two thirds to Rainbow Creek if the environmental flow at Cowwarr Weir is equal to or less than 125 ML/day;
- appropriate rules for sharing higher flows including flood flows; and
- during periods of maintenance on Cowwarr Weir, arrangements for:
  - Maintaining a minimum flow of 25 ML/day; and
  - Protecting the water quality in the old course of the Thomson River.

**Landcare Groups**

Landcare groups that seek funding from the Natural Heritage Trust are required to submit vision statements to provide a context for their proposed works. Example vision statements are provided in Appendix 7. Most relate to the improvement or reinstatement of native vegetation in the riparian zone to stabilise banks and provide habitat corridors along and between waterways.

# APPENDIX 3 ASSESSMENT OF PRIOR CONDITION

## A3.1 Flow regulation and hydrology

***Flow regulation and diversion***

*Thomson River*

Regulation of the lower Thomson River began in 1957 with the construction of Cowwarr Weir to control the relative volumes passing down Rainbow Creek and Old Thomson River. Without the structure, less water would flow down the Old Thomson channel. The weir is also operated to divert water to the Nambrok-Denison irrigation area and for water supply to Tyers-Glengarry townships. There are five offtakes from Cowwarr Weir:

- Rainbow Creek – flow released through weir sluice gates
- Old Thomson River channel – flow over weir
- Connecting channel – flows over drop bar regulator to Old Thomson River. Helps to control flow to Old Thomson River during high flow events when the weir may be blocked
- Cowwarr Channel – irrigation channel offtake. Design capacity is 950 ML/d
- Rosedale Water Board Pump Station – water supply to Tyers-Glengarry townships.

Although the weir has a relatively small capacity (2,500ML) compared with flood flow volumes, it has an impact on high flows in Old Thomson River and Rainbow Creek. For example, during high flows the weir sluice gates are automatically raised to regulate the relative proportions of water moving down these two channels. Also, episodes of zero flows occur annually in the Old Thomson River during the non-irrigation period when the weir is dewatered for maintenance.

Diversion from the river's headwater began in 1967, upstream of the construction site for the Thomson Dam. The Thomson Dam was closed in 1983 and filling took place over several years until the dam first spilled in 1993. Since 1990, releases from the dam have been managed for hydroelectricity production at the dam wall. The capacity of Thomson dam is 1.1 x $10^6$ ML, which is over 4 times the mean annual inflow to the dam. As a consequence, all but the largest flood peaks are eliminated from the flow regime immediately downstream of the dam.

The reach of the Thomson River from Cowwarr Weir to the confluence with Rainbow Creek, also known as the "Old Thomson River", has a length of 28.8 km and a bankfull capacity of 7,500 ML/d (Brizga & Finlayson, 1990). There are 41 diverters along this stretch with a total licensed allocation of 6,302 ML $year^{-1}$ (K. Bates, SRW, pers. comm.). The total catchment area at Cowwarr Weir is 1,080 $km^2$.

The reach of Rainbow Creek from Cowwarr Weir to the confluence with the Thomson River is a breakaway that occurred in 1952. It has a length of 14.8 km, a bankfull capacity of 24,400 ML, and has a longitudinal profile that is nearly twice as steep as the Old Thomson channel. There are 33 diverters with an allocation of 5,440 ML $year^{-1}$ that divert water from Rainbow Creek (an additional 3 customers have an allocation of 245 ML $year^{-1}$ directly from Cowwarr Weir).

The reach of the Thomson River from confluence of Rainbow Creek to the Latrobe River is 33.3 km long. Water is abstracted from the Thomson upstream of the Macalister confluence, (4,885 ML $year^{-1}$ is allocated to 42 diverters), and water is returned to the river via irrigation drainage and surface runoff, particularly via Cowwarr Channel and Boggy Creek.

*Macalister River*
The construction of Lake Glenmaggie was completed in 1927. The lake has a capacity of 190,000 ML and a catchment area of1891 $km^2$. Maffra Weir was constructed in 1950's.

The reach of the Macalister River downstream from Lake Glenmaggie to Maffra Weir is approximately 37 km. The catchment area above Maffra Weir is 2072 km2. Water is diverted from Lake Glenmaggie to supply irrigators via the Main Northern and Main Southern channels. In addition, 22 diverters with an annual allocation of 1,692 ML, pump water directly from the river.

The Macalister River downstream from Maffra Weir to the Thomson River confluence travels 18km. The total catchment area is 2330 km2 at the confluence with the Thomson River (Erskine *et al*., 1990). Water is supplied to irrigators from Maffra Weir. In addition, 24 diverters with an annual allocation of 1,961 ML, pump water from the river.

***Impact of Regulation on Flows***
Figures 10 and 11 show the impact of flow regulation on hydrology in the lower Thomson River by comparing the regulated flow regimes at Wandocka (1990-1999) and Heyfield (1992-1997) with the natural flow regime at Cowwarr (1923-1951).

A similar analysis of flow in the Macalister River since the construction of Lake Glenmaggie has not yet been undertaken. Such an analysis is highly recommended and is possible with existing data.

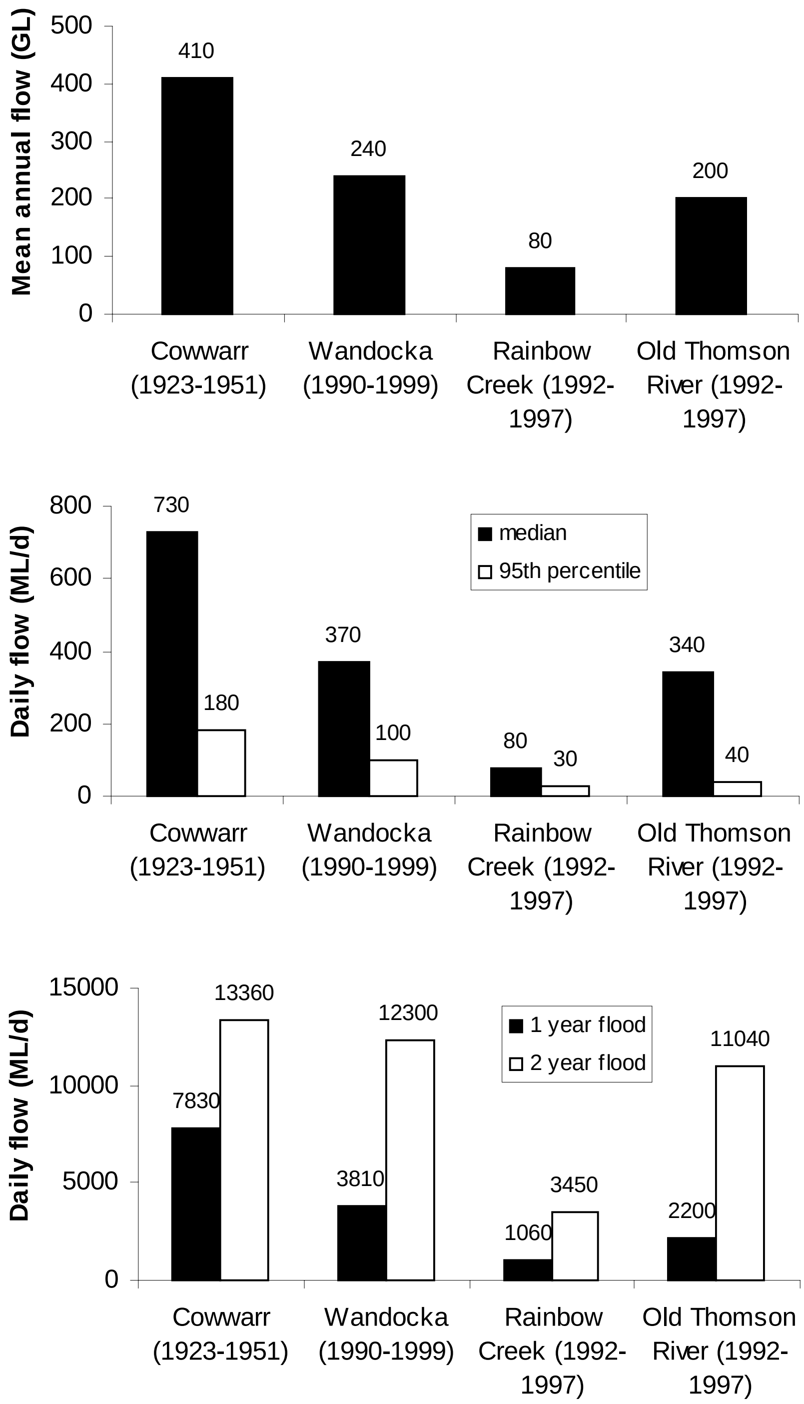
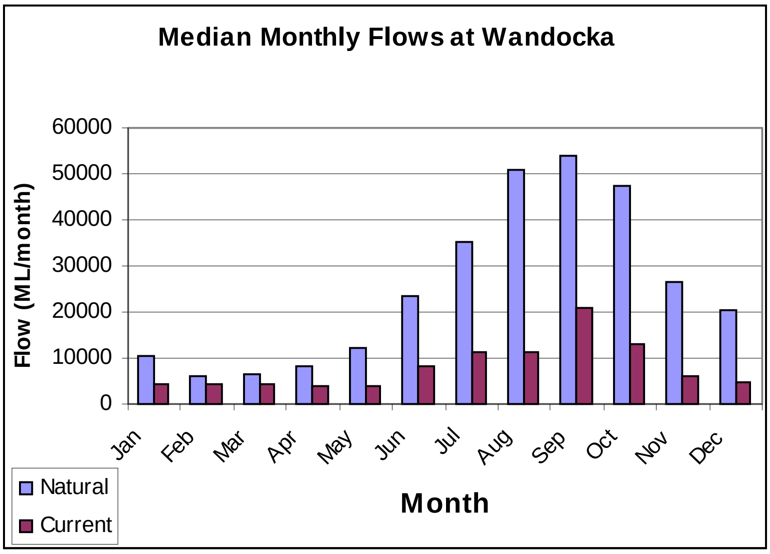
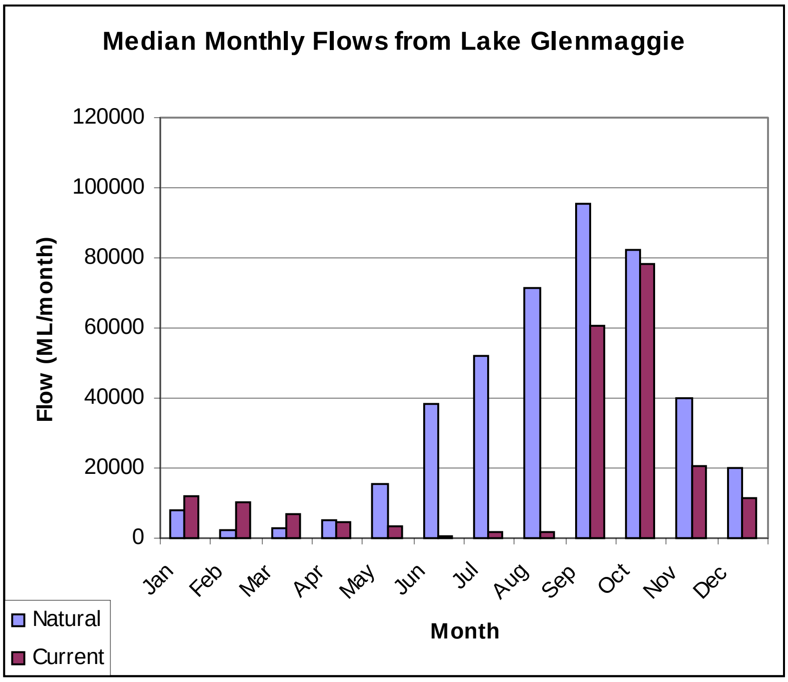



**Figure 10: Flow statistics at Cowwarr prior to regulation, and at Wandocka and Heyfield (Rainbow Creek and Old Thomson River channels) during the most recent phase of regulation.**




(a)




(b)

**Figure 11: Comparison of natural and current median monthly flows in the Thomson River at Wandocka (a) and downstream from Lake Glenmaggie (b)**

Flows at Cowwarr Weir are split into two channels: the Old Thomson River and Rainbow Creek. The following points summarise the impact of regulation; a more detailed description of the hydrological regimes at these sites is provided in the followng sections:

- Flow regulation has increased the duration of low and medium flows and reduced the frequency of in-channel high flow events in the lower Thomson River. However, flow regulation has had little effect on the duration or frequency of flooding due to flows from the unregulated Aberfeldy River.
- The most heavily regulated section of the lower Thomson River is the 15 km reach referred to as Rainbow Creek

    - Recently, the sluice gates at Cowwarr Weir have been managed so that approximately 70% of the inflow to Cowwarr Weir passes along the Old Thomson River channel and 30% along Rainbow Creek.
    - Between 1992 and 1997, the median flows in Rainbow Creek and Old Thomson River at Heyfield were respectively 10% and 50% of the median flow that occurred naturally in the Thomson River at Cowwarr.
    - The 95$^{th}$ percentile flow in Rainbow Creek and Old Thomson River at Heyfield are similar and approximately 20% of natural the 95$^{th}$ percentile flow at Cowwarr.
- The flow regime at Wandocka is similar to the regime in the Old Thomson River at Heyfield but slightly less altered from natural as a result of Rainbow Creek inflows. The 1 year flood peak at Cowwarr prior to regulation corresponds to a 1.5 year flood peak at Wandocka in the current regime. Flood peaks at Wandocka with a recurrence interval greater than 2 years are little affected by flow regulation.

While the median annual flow in the lower Thomson River has been reduced by approximately 50% since regulation (CRCFE 1999), the general pattern of the flow regime has remained unchanged (Figure 11a) due to inputs from the unregulated Aberfeldie River. However, the pattern of flow in the lower Macalister River below Lake Glenmaggie (Figure 11b) has changed significantly since regulation. The lower Macalister River now experiences higher than natural summer flows, and very low flows in winter when flow would naturally be high. These differences between the two rivers mean that different approaches to flow rehabilitation will be required.

Based on limited available information, the CRCFE (1999) made a number of recommendations that would address flow management issues in the lower Thomson and Macalister Rivers, including:

- Thomson River:
    - A minimum environmental flow of 130 ML/d (or natural); again note that the 1996 MOU requires that monthly environmental flows ranging from 150-245 ML/d be met at Coopers Creek gauging station upstream of Cowwarr Weir;
    - This flow to pass the entire length of the lower Thomson to the confluence with the Latrobe River;
    - An improved release plan from Cowwarr Weir be developed to ensure the present large daily fluctuations in water level in the river are minimised;
    - Further work aimed at modifying the operation of Thomson Dam so that a greater proportion of the small to medium size flow events pass down the lower Thomson River (these flows to improve fish spawning and migration, channel maintenance and formation, and connection between the channel and the floodplain).
- Macalister River:
    - A minimum environmental flow of 130 ML/d (or natural);
    - Passage of this flow down the entire length of the lower Macalister to the confluence with the Thomson River;
    - Releases from Lake Glenmaggie and Maffra Weir, with the aim of minimising the large daily fluctuation in water level in the river;
    - Adoption of a translucent dam approach for the operation of Lake Glenmaggie;
    - Undertaking further translucent dam modelling studies as a priority with a view to maximising passing flows (with acceptable security of supply; fish spawning and migration flows; channel formation flows; potential for channel-floodplain connection;
    - Introduction of a fishway through Maffra Weir and investigation of the feasibility of also introducing a fishway through Lake Glenmaggie.

***Additional hydrological data for the lower Thomson River***

Available data has been used to assess hydrological changes to the lower Thomson River. The data exists to undertake a similar analysis for the lower Macalister River.

*Availability of Streamflow Data*

Gippel *et al.* (1993) identify 4 distinct phases (Figure 12) in the development of flow regulation in the lower Thomson River:

- The 1st phase began in 1957 with the construction of Cowwarr Weir;
- The 2nd phase began in 1967 with the onset of diversion upstream of the Thomson Dam construction site;
- The 3rd phase began with the completion of Thomson dam in 1983;
- The 4th phase began with the operation of the hydropower plant at the dam wall in 1990.

Gippel *et al.* (1993) assessed the effects of flow regulation on the lower Thomson River during 2nd, 3rd phases of regulation. This analysis (below) provides an assessment of the impact of regulation during the most recent phase (1990 to date).

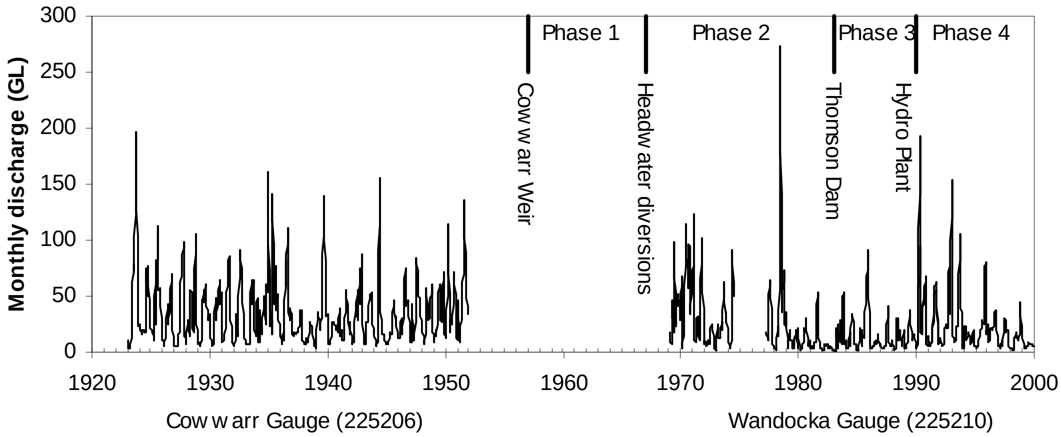



**Figure 12: Monthly discharges for the lower Thomson River at Cowwarr (1923 to 1951) and Wandocka (1968 to 1999)**

*The "Natural" Flow Regime*

A streamflow gauge was in operation at Cowwarr between March 1922 and December 1952 (Gauge Number 225206) before the construction of Cowwarr Weir. This 30 year record of "natural" streamflows provides a sound baseline against which we can evaluate the hydrological impact of regulation.

*Existing Flow Regime in Thomson River at Wandocka*

Gippel *et al*. (1993) used streamflow records from the Wandocka streamflow gauge (Number 225212) to characterise the flow regimes of the 2nd and 3rd phases of regulation in the lower Thomson River. This gauge is located downstream of the confluence of Rainbow Creek and the Old Thomson River but upstream of the Macalister River confluence. Insufficient data was available to characterise the first phase of regulation and Gippel *et al.* (1993) had only two years of data (1990-1991) with which to characterise the 4th and most recent phase of diversions. This analysis (below) builds on the work of Gippel *et al.* (1993) by providing an assessment of flow regulation since the hydropower plant began operation in 1990. The pre-regulation flow regime at the Cowwarr gauge (1922-1952) is used for comparison. However, it should be noted that the catchment area at Wandocka is 1417 $km^2$ compared to 1088 $km^2$ at the Cowwarr gauge, with tributaries along the Old Thomson River (and in particular Stony Creek) contributing much of this additional catchment area. As a result, the comparison between regulated flows at Wandocka withand "natural" flows at Cowwarr underestimates the impact of regulation. Ideally, a "natural" flow record should be simulated at Wandocka for use as a baseline for assessing the impacts of regulation. It is strongly recommended that this be done before hydrological targets for environmental flow releases are finalised.

*Existing Flow Regime in Rainbow Creek and Old Thomson River at Heyfield.*
The Thomson River flows are split at Cowwarr Weir between Rainbow Creek and the Old Thomson River. Rainbow Creek and old Thomson Channel flow 14.8 km and 26.6 km respectively across the floodplain before rejoining downstream of Heyfield. Water is diverted directly from Old Thomson River and Rainbow Creek during the drier months by riparian landowners. Gippel *et al*. (1993) estimate the median diversion rates for the summer months at around 20 ML/d. These diversions can substantially reduce summer flows in Old Thomson River and Rainbow Creek. The flow regimes in these two channels of the Thomson River (Rainbow Creek and Old Thomson River) reflect the cumulative effects of:

- Flow regulation at Thomson Dam,
- Flow diversions at Cowwarr Weir,
- Private diversions downstream of Cowwarr Weir, and
- The flow "split" itself, controlled by the sluice gate on Cowwarr Weir.

The cumulative effects of regulation are assessed using flow data recorded at the two Heyfield gauges located just upstream of the confluence of Rainbow Creek and Old Thomson River (Numbers 225236 in Rainbow Creek and 225200 in Old Thomson River) (Figures 13 to 20; Table 10). Both gauges began operation in 1992 and were only rated for flows less than 300 ML/d in Old Thomson River and 660 ML/d in Rainbow Creek. Data for the most recent phase of regulation (May 1992 to April 1997) are used for this assessment and compared with pre-regulation flows at Cowwarr. Higher "unrated" flows were estimated using the Wandocka streamflow record[2]. Thiess Environmental Services have not operated these gauges since 1997. It recommended that if available[3], data for the period 1997 to 1999 should be included in this analysis.

[2] Where only one of the Heyfield gauges was operating in the "un-rated" range of higher flows, flow at this gauge were estimated as the Wandocka flow less flow recorded at the other Heyfield gauge. At least one of the Heyfield gauges operated for 91% of the time. Periods when neither gauge was operating in the rated range were generally during high flow events with an average duration of 5 days. There was generally little difference in the flow passing down the two channels expressed as a percentage of flow recorded at Wandocka before and after these events (average change of 20%). Daily flows during these events were estimated as a percentage of Wandocka flows, where the percentage was interpolated linearly through these high flow events.

[3] Southern Rural Water may hold these more recent data

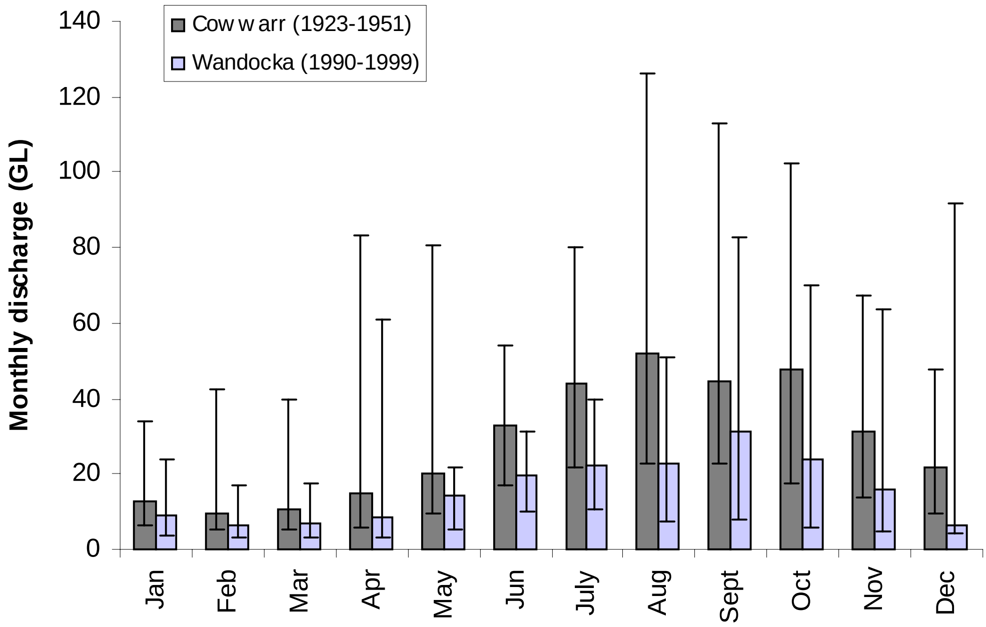



**Figure 13: Median monthly discharges for the lower Thomson River (whisker bars indicate 5th and 95th percentile monthly flows)**

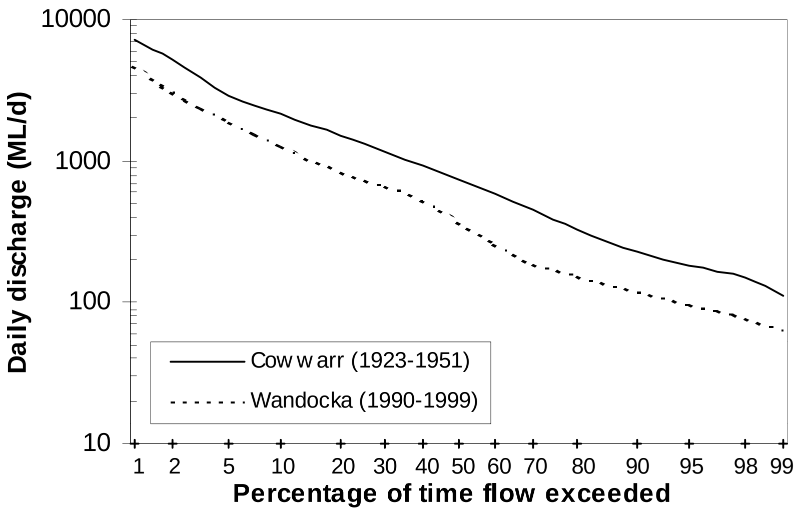



**Figure 14: Daily flow duration curves for the lower Thomson River**

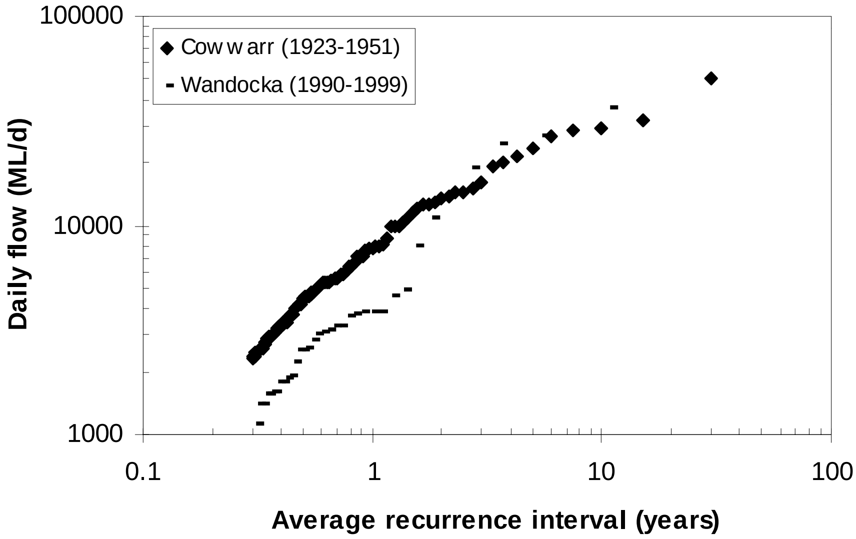



**Figure 15: Partial duration flood series for the lower Thomson River**

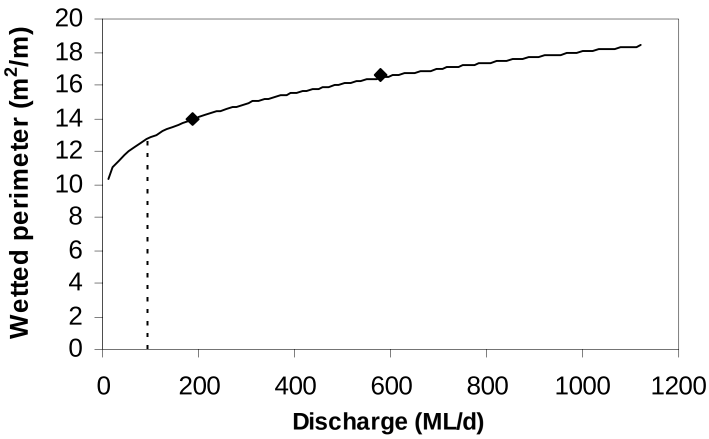



**Figure 16: The relation between wetted perimeter and discharge at Wandocka, Thomson River (The diamonds indicate wetted perimeter estimated from surveys. The curve is a modelled relation. The dashed line indicates the break-point defined using the gradient method of Gippel and Stewardson (1998)**

**Table 10: Recurrence interval and duration of particular flow events in the lower Thomson River**

| | *Cease to flow* | *Bed exposure Q < 95 ML/d* | *Minor flood Q > 13.2 GL/d* | *Major flood Q > 19.4 GL/d* |
|---|---|---|---|---|
| **Average recurrence interval (yrs)** | | | | |
| Cowwarr (1923-1951) | none | 7.5 | 1.9 | 3 |
| Wandocka (1990-1999) | none | 0.7 | 2 | 3.3 |
| Rainbow Creek (1992-1997) | none | 0.6 | 5 | none |
| Old Thomson River (1992-1997) | none | 0.4 | 2.5 | 5 |
| **Average duration (days/event)** | | | | |
| Cowwarr (1923-1951) | - | 11.3 | 1.9 | 1.2 |
| Wandocka (1990-1999) | - | 11.1 | 1.8 | 1.3 |
| Rainbow Creek (1992-1997) | - | 120 | 1 | - |
| Old Thomson River (1992-1997) | - | 33 | 1.5 | 1 |

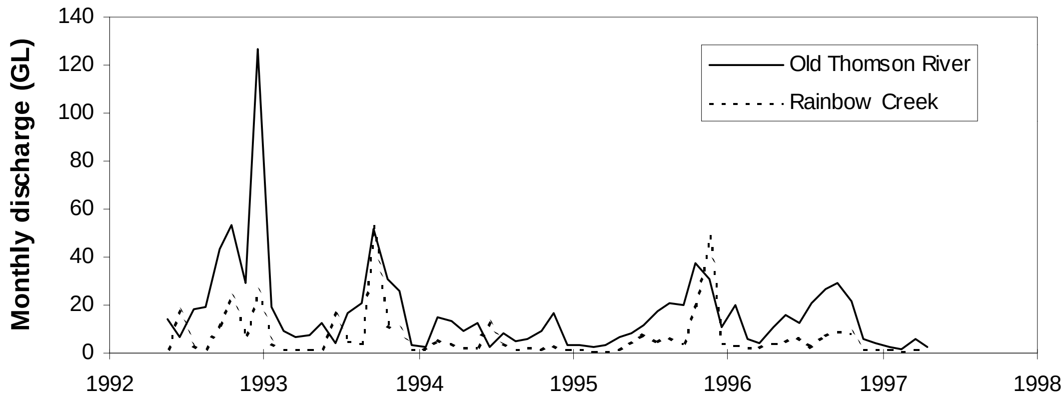



**Figure 17: Monthly flows in Rainbow Creek and Old Thomson River at Heyfield (May 1992 April 1997)**

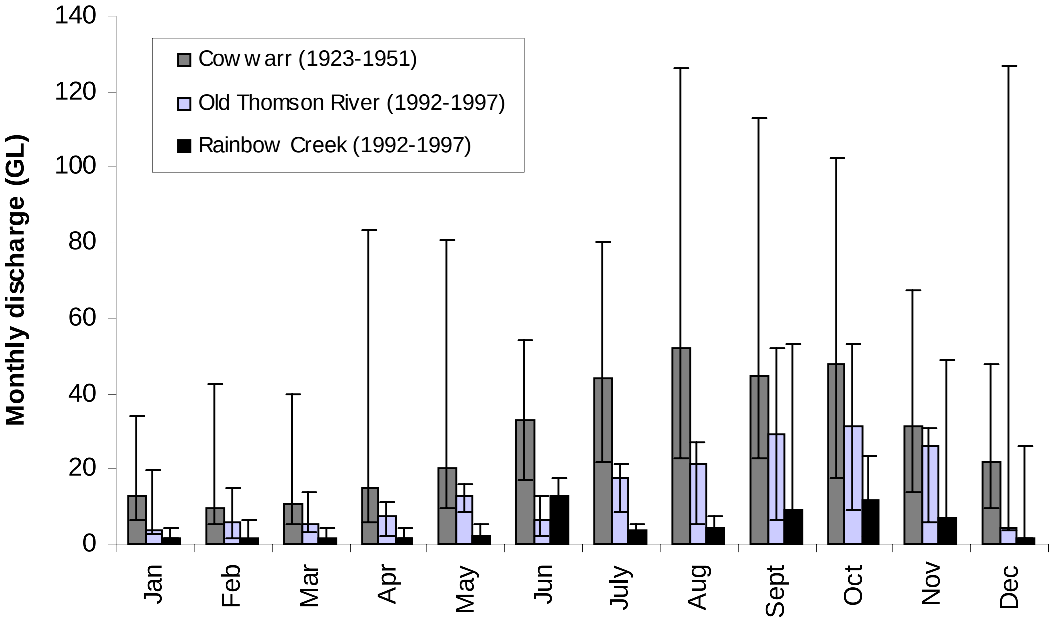



**Figure 18: Median monthly discharges for Rainbow Creek and Old Thomson River (whisker bars indicate 5th and 95th percentile monthly flows for Cowwarr and maximum and minimum flows at Heyfield gauges)**

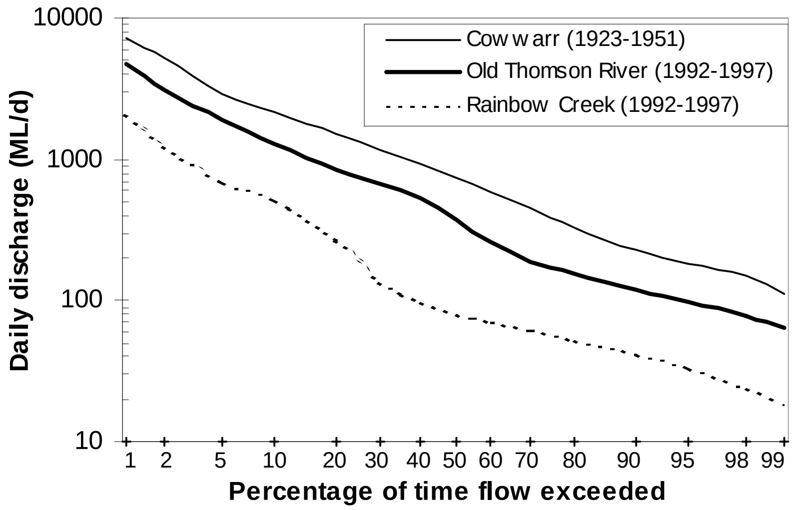



**Figure 19: Daily flow duration curves for Rainbow Creek and Old Thomson River**

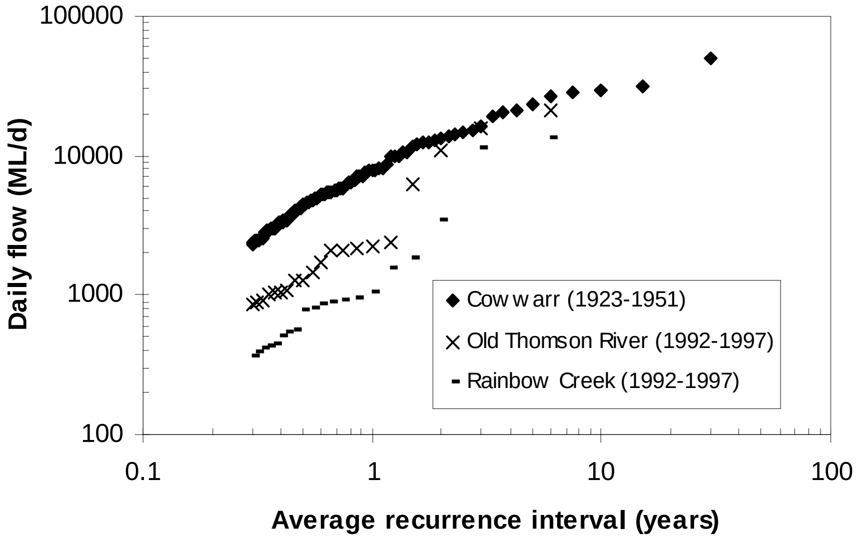



**Figure 20: Partial duration flood series for Rainbow Creek and Old Thomson River**

## A 3.2 Geomorphology

River channel instability is a feature of the Thomson and Macalister River systems. Rescan *et al*. (1990) cite the following evidence of major channel changes in these two rivers:

- Channel avulsions;
- Meander cutoffs;
- Channel widening and straightening;
- Bed lowering.

Jones (1985) and Brizga (1989) have also noted major changes to channel morphology since European settlement. The causes of these river channel changes include:

- Catastrophic floods or sequences of floods;
- The excellence of geomorphic thresholds; and
- Direct human modifications to the river through artificial cutoffs and desnagging.

As a result both the Thomson and Macalister rivers have been the focus of active river channel management. Rescan *et al*. (1990) suggest that most of the river channels in the catchment are now relatively stable or are in a period of recovery. The Macalister River downstream of Lake Glenmaggie is an exception, where the potential for significant channel erosion still exists.

The physical condition of the in-channel environment in the Thomson and Macalister rivers was generally poor (Table 11). At all sites inspected in 1999, there were limited in-channel structures in terms of the number and size of riffle/pool sequences, sediment bars, benches or back water areas. At some locations channel works were the dominant physical structure in the channel.

***Rainbow Creek***

The avulsion of Rainbow Creek in 1952 was an event consistent with the evolution of this type of river system. The old channel of the Thomson River is perched on an alluvial ridge and would have experienced a declining channel capacity over a long period of time. Under these circumstances each time there was a flood which exceeded the channel capacity, the overbank flows would have concentrated on the lowest part of the floodplain and begun to develop a new channel there. As the channel capacity of the old course declined, the rate of development of the new channel would have accelerated.

Under natural conditions (i.e. before European colonists cleared the floodplain for farming), the floodplain would have supported an open forest, probably with many large trees scattered across the area. The newly formed channel has a higher gradient than the old channel and because it is on the lowest part of the floodplain, flow is concentrated in it and it is actively eroding as it develops sinuosity. If the floodplain had not been cleared, this erosion would have undermined these large trees which would then have formed a population of large woody debris (LWD) in the channel. The exact effect the LWD wold have had on the channel form and the rate of development of such a channel is not clear, but channel expansion might have been retarded as more water was forced onto the floodplain. It is also the case that the LWD would have provided important habitat elements in the new channel.

In the 1952 avulsion, which occurred across a largely cleared floodplain, the channel probably eroded its banks and migrated more actively than if the floodplain had not been cleared and the channel certainly provided less variety of habitat structure.

**Table 11: Physical condition of the various reaches in the Thomson - Macalister River system (from CRCFE 1999).**

| Reach | Comments |
|---|---|
| Reach 1<br>Thomson river from Cowwarr Weir to the Rainbow Creek Confluence | • Extensive floodplain with many flood runners and secondary channels.<br>• The floodplain is highly degraded with many of the floodplain channels being either drained or blocked to prevent natural connectivity between the main channel and floodplain. The construction of levees has also interrupted this natural connectivity.<br>• Suspended load, highly sinuous channel. The in-channel environment contains riffle pool sequences, sediment bars and benches. The river appears to be contracting due to a reduction in flushing flows, which increases the probability of channel sedimentation.<br>• Many of the large pools also appear to be infilling due to the accumulation of fine sediment. |
| Reach 2<br>Rainbow Creek | • A high energy, mixed load channel. This reach is the avulsed channel of the Thomson River. As such it has undergone significant river channel change. Although it considered to be in a recovery phase. Hence, there may be a change in the focus of geomorphic processes i.e. more constructional than erosional.<br>• Parts of the in-channel environment are depauperate in physical structure with limited riffle/pool sequences and sediment bars. |
| Reach 3<br>Thomson River from the Rainbow Creek confluence to the Latrobe River | • Extensive floodplain with many flood runners and secondary channels.<br>• The floodplain is degraded with many of the floodplain channels being drained or blocked thus preventing the natural connectivity between the main channel and floodplain. The construction of levees has also interrupted this natural connectivity.<br>• The channel in this reach resembles a suspended load channel with relatively high sinuosities and low width to depth ratios.<br>• Bank erosion scars were noted through out this reach which may suggest some form of channel instability. The channel banks would be susceptible to rapid falls in water level.<br>• There is a limited amount of in-channel structure such as riffle pool sequences. |
| Reach 4<br>Macalister river from Lake Glenmaggie to Maffra Weir | • Extensive floodplain with many flood runners and secondary channels.<br>• The floodplain is degraded with many of the floodplain channels being drained or blocked thus preventing the natural connectivity between the main channel and floodplain.<br>• The river has a mixed load channel. Parts of which are actively eroding the bed and banks presumably due to natural channel adjustments and in response to the presence of Lake Glenmaggie. It is considered that these adjustments will continue to reduce the structural complexity of the in-channel environment.<br>• The gravel bed substratum displays signs of fine sediment accumulation and thus the deterioration of this as a microhabitat for benthic organisms. |
| Reach 5<br>Macalister River from Maffra Weir to the Thomson River | • Extensive floodplain with many flood runners and secondary channels.<br>• The floodplain is degraded with many of the floodplain channels being drained or blocked thus preventing the natural connectivity between the main channel and floodplain.<br>• This reach is characteristic of a suspended load channel.<br>• The presence of numerous bank erosion scars may suggest this reach is actively eroding its banks. The channel banks are considered to be unstable particularly to rapid falls in water levels. |

### A3.3 Riparian and Aquatic Vegetation

There is very little information on the state of riparian vegetation from which to quantify changes since European settlement. Jones (1985) reviewed historic information to describe the nature of the Macalister River and its floodplain since the 1840's. Historic records described the area as 'open plain with occasional narrow belts of forest'. Early maps indicated riparian forest along watercourses and wetland areas in depressions, with grasslands on the floodplain. Other historic records quoted by Jones (1985) describe in the early parts of the twentieth century ‘fertile plains, then in most places knee high in grasses’ or ‘a bowl fringed with tall gum trees towering over wattles…. and small shrubs bearing edible berries’.

Current maps and aerial photographs, anecdotal records of River Improvements Trusts, along with site visits (CRCFE 1999) suggest that the riparian zone along the river systems has been extensively modified since European settlement. In many instances, the riparian zone has been reduced to a thin line of trees or shrubs with an understorey of grass, significantly different to the extensive riparian and wetland system represented on maps of the 1850’s (Jones 1985).

One section of the lower Thomson River remains relatively undisturbed, because local River Improvement Trusts have not undertaken works such as removing large woody debris (LWD or snags) or the clearing of riparian vegetation. Nearby wetlands and billabongs also remain, although their flooding and drying regime may have been affected by river regulation. Investigations of this section of the river by Gippel *et al*. (1996) identified a loading of woody debris that was comparable with that of some headwater streams and suggested that a similar loading should be the target for rehabilitating lowland rivers. Gippel *et al.* also found that the orientation of the woody debris at the site on the lower Thomson was such that there was generally only a minimal influence on hydraulics. Their calculations indicated that desnagging of the river section would only reduce bankfull discharge by a maximum of 0.2% of river depth, although this did not account for potential long-term effects such as increased bed and bank erosion due to the removal of the sediment storing capacity associated with woody debris. The relatively intact nature of the riparian zone in this section of the river means that it may serve as a useful guide for setting rehabilitation targets for the riparian zone along other river reaches in the study area.

No information has been found about the aquatic vegetation of the river system. However, it might be expected that aquatic vegetation, like riparian vegetation, has been extensively modified since European settlement, due to stream bed and bank erosion, river management works, access by livestock and a decline in water quality, especially in the lower sections of the study area.

### A3.4 Native Fish

The following section should be read in conjunction with section 3.3 from the CRCFE (1999) report, which provides a detailed discussion regarding current impacts on the fish fauna. The following discussion provides more detail on a few key areas.

The following lists of fish species for the Thomson and Macalister rivers has been compiled from surveys reported by:

- Hall 1989 (survey conducted in 1988 in Rainbow Creek – 1 site, Thomson River – 3 sites, Macalister River – 2 sites):
- Raadik 1996 (pre-fishway survey, 6 sites in Thomson River around Cowwarr Weir during 1996);
- Raadik (unpublished) (post-fishway survey, Rainbow Creek – 1 site and Thomson River 3 sites around Cowwarr Weir in 1999); and
- Tunbridge unpublished survey data for Thomson River (Thomson Dam project).

No surveys have been conducted in the wetland/billabong habitat associated with the river systems and very few surveys have been conducted in tributary streams. The fish species likely to be present in the Thomson and Macalister systems are listed in Table 12.

The diversity of native species does not appear to have changed from historical records (Table 13), but alien species have become established, and native fish community structure and individual species abundances are likely to have changed dramatically (Table 14). The major change to fish populations since European settlement is thought to consist of a decrease in abundance and distribution for some species (e.g. River Blackfish contracted in range further up each system), decreased abundance for many species and increased abundance in main channel sites for some species (e.g. Southern Pygmy Perch) because of reduced flows in the system. Australian Bass is likely to be the main native recreational fish species. Australian Grayling may once have been a recreational species but is now protected under the Flora and Fauna Guarantee Act.

**Table 12: Fish species recorded from or thought to be present in the Thomson-Macalister River system.**

| Common Name | Scientific Name | State Conservation Status[1] | National Conservation Status[2] |
|---|---|---|---|
| **Native Species** | | | |
| **Migratory** | | | |
| Short-headed Lamprey | *Mordacia mordax* | | |
| Pouched Lamprey | *Geotria australis* | | |
| Short-finned Eel | *Anguilla australis* | | |
| Long-finned Eel | *Anguilla reinhardtii* | | |
| Broad-finned Galaxias | *Galaxias brevipinnis* | | |
| Common Galaxias | *Galaxias maculatus* | | |
| Spotted Galaxias | *Galaxias truttaceus* | | |
| Australian Grayling | *Prototroctes maraena* | FFG, Vulnerable | Vulnerable |
| Australian Smelt[?] | *Retropinna semoni* | | |
| Australian Bass | *Macquaria novemaculeata* | | |
| Cox's Gudgeon | *Gobiomorphus coxii* | FFG, Endangered | |
| Striped Gudgeon | *Gobiomorphus australis* | Vulnerable | |
| Tupong | *Pseudaphritis urvillii* | | |
| **Non-migratory** | | | |
| Mountain Galaxias | *Galaxias olidus* | | |
| Dwarf Galaxias | *Galaxiella pusilla* | FFG, Lower Risk | Vulnerable |
| Southern Pygmy Perch | *Nannoperca australis* | | |
| River Blackfish | *Gadopsis marmoratus* | | |
| Flatheaded Gudgeon | *Philypnodon grandiceps* | | |
| **Alien Species** | | | |
| Goldfish | *Carassius auratus* | | |
| Carp | *Cyprinus carpio* | | |
| Eastern Gambusia | *Gambusia holbrooki* | | |
| Rainbow Trout | *Oncorhynchus mykiss* | | |
| Redfin | *Perca fluviatilis* | | |
| Brown Trout | *Salmo trutta* | | |

**1 –** listed as threatened in Victoria (NRE 1999. Threatened Vertebrate Fauna in Victoria – 1999. DNRE). **FFG –** listed on the Victorian *Flora and Fauna Guarantee Act* 1988.
**2 –** Listed as Nationally threatened.

River regulation is likely to affect the direction and season of fish migration, and possibly the initiation cues for biological processes such as gonad development and maturation. For example, Broad-finned and Spotted Galaxias adults spawn at upland sites but do not migrate downstream; larvae are washed downstream and the juveniles migrate back upstream. Barriers to migration, such as weirs, can affect this upstream migration. For Australian Bass, adults migrate downstream to spawn in winter and back upstream during spring/summer; increasing flow in winter is the potential cue for the downstream migration. Tupong and Bass juveniles migrate upstream during spring-summer; flow may also play a role in this migration.

Off-stream wetland habitats are important for the nationally threatened Dwarf Galaxias, as well as many other species (see Tables 12 to 14). Some species spend their entire life-cycle in this habitat, others are found in both wetlands and main channel sites (e.g. Common Galaxias and Southern Pygmy Perch), and other migrate in and out for varying reasons (e.g. Tupong, eels, Australian bass). Connectivity is essential, and wetlands provide habitat types and conditions different from those in the main channel areas.

**Table 13: Proposed historical distribution and abundance of fish species in the Thomson and Macalister Rivers.**

| Common Name | Thomson R | | Macalister R | |
|---|---|---|---|---|
| | Main Channel | Billabong/ Wetland | Main Channel | Billabong/ Wetland |
| **Native Species** | | | | |
| **Migratory** | | | | |
| Short-headed Lamprey | F,C | - | F,C | - |
| Pouched Lamprey | F,C | - | F,C | - |
| Short-finned Eel | F,C | F,C | F,C | F,C |
| Long-finned Eel | F,C | F,C | F,C | F,C |
| Broad-finned Galaxias | F,C | - | F,C | - |
| Common Galaxias | F,C | F,C | F,C | F,C |
| Spotted Galaxias | F,C | I,R | F,C | I,R |
| Australian Grayling | F,C | - | F,C | - |
| Australian Smelt[?] | F,C | - | F,C | - |
| Australian Bass | F,C | I,C | F,C | I,C |
| Cox's Gudgeon | F,C | - | F,C | - |
| Striped Gudgeon | F,C | F,C | F,C | F,C |
| Tupong | F,C | I,R | F,C | I,R |
| **Non-migratory** | | | | |
| Mountain Galaxias | F,C | - | F,C | - |
| Dwarf Galaxias | A | F,C | A | F,C |
| Southern Pygmy Perch | I,C | F,C | F,C | F,C |
| River Blackfish | F,C | - | F,C | - |
| Flatheaded Gudgeon | F,C | F,C | F,C | F,C |
| **Alien Species** | | | | |
| Goldfish | - | - | - | - |
| Carp | - | - | - | - |
| Eastern Gambusia | - | - | - | - |
| Rainbow Trout | - | - | - | - |
| Redfin | - | - | - | - |
| Brown Trout | - | - | - | - |

Potential Occurrence: F – Frequent found, I – infrequent found, "-" - absent
Abundance: C – common, R - rare

**Table 14: Current knowledge of the distribution and abundance of fish species in the Thomson and Macalister Rivers, and Rainbow Creek.**

| Common Name | Thomson River | | Rainbow Creek | | Macalister River | |
|---|---|---|---|---|---|---|
| | Main Channel | Billabong /Wetland | Main Channel | Billabong /Wetland | Main Channel | Billabong /Wetland |
| **Native Species** | | | | | | |
| **Migratory** | | | | | | |
| Short-headed Lamprey | F,C | A | F,C | A | F,C | A |
| Pouched Lamprey | F,C? | A | F?,C? | A | F,C? | A |
| Short-finned Eel | F,C | F?,C? | F,C | F?,C? | F,C | F?,C? |
| Long-finned Eel | F,C | F?,C? | F,C | F?,C? | F,C | F?,C? |
| Broad-finned Galaxias | F?,C? | A | F?,C? | A | F,C? | A |
| Common Galaxias | F,C | F?,C? | F,C | F?,C? | F,C | F?,C? |
| Spotted Galaxias | F?,R? | I?,R? | F?,R? | I?,R? | F,R? | I?,R? |
| Australian Grayling | I?,C? | A | I?,R? | A | I?,R? | A |
| Australian Smelt? | F,C | A | F,C | A | F,C | A |
| Australian Bass | F?,C? | I?R? | I?R? | A | F?,C? | I?,R? |
| Cox's Gudgeon | I,R | A | I?,R? | A | I,R | A |
| Striped Gudgeon | F?,R? | F?,R? | F?,R? | F?,R? | F?,R? | F?,R? |
| Tupong | F,C | I?,R? | F,R | I?,R? | F,C | I?,R? |
| **Non-migratory** | | | | | | |
| Mountain Galaxias | I?,R? | A | A | A | I?,R? | A |
| Dwarf Galaxias | A | I?,R? | A | I?,R? | A | I?,R? |
| Southern Pygmy Perch | F,C | F?,C? | F,C? | F?,C? | F,C | F?,C? |
| River Blackfish | F,C | A | F,C | A | F,C | A |
| Flatheaded Gudgeon | F,C | F?,C? | I,R | F?,C? | F,C | F?,C? |
| **Alien Species** | | | | | | |
| Goldfish | I,R | F?,C? | I?,R? | F?,C? | | F?,C? |
| Carp | F,C | F?,C? | F,C | F?,C? | | F?,C? |
| Eastern Gambusia | F,C | F?,C? | F,C | F?,C? | | F?,C? |
| Rainbow Trout | I?,R? | A | I?,R? | A | | A |
| Redfin | F,C | F?,C? | F,C | F?,C? | | F?,C? |
| Brown Trout | F,C | I?,R? | F,C | I?,R? | | I?,R? |

Potential Occurrence: F – Frequent found, I – infrequent found, A - absent
Abundance: C – common, R - rare
? – unknown or unsure (lack of survey data)

### A3.5 Macroinvertebrates

There are no historic records against which changes to macroinvertebrate populations in the rivers since European settlement can be assessed directly. Macroinvertebrate sampling has been conducted in the study area to assess changes following the construction of Thomson Dam and as part of ongoing river health assessments (CRCFE 1999). The EPA has sampled macroinvertebrates in the Gippsland region as part of the National River Health Program and assessed populations using AUSRIVAS modelling (Appendix 5). AUSRIVAS predicts the macroinvertebrate fauna expected to occur at a site with specific environmental characteristics, in the absence of human induced stresses. The number of families observed (O) at a site can then be compared to fauna expected (E), with the deviation between the two providing an indication of biological condition. Samples for analysis are usually collected from either edge or riffle areas (or both) in spring and in summer. The results for sites in the study area are presented in Table 15. Macroinvertebrates collected from the edge of the main river channels indicated good to moderate conditions. Conditions in tributaries such as Newry Creek were moderate to degraded. It is interesting to note that the invertebrates sampled from the Thomson River at Wandocka are indicative of a river in good condition. The site has cobbly substrate, a considerable amount of native riparian vegetation and relatively good water quality, when compared with other lowland rivers in Gippsland. It may be possible to use this site as a 'reference' against which to assess the effects of rehabilitation in other areas of the lower Thomson and Macalister Rivers.

**Table 15: AUSRIVAS assessment of sites in the region (based on edge samples, spring and summer)**

| Site Location | Assessment |
|---|---|
| Macalister R. @ Bellbird Corner | B |
| Newry Ck @ Lower Newry Rd | B |
| Newry Ck @ Boisdale Rd | B |
| Newry Ck @ Upper Maffra Rd | C |
| Thomson River @ Wandocka | A |
| Thomson River @ Bundalaguah | B |
| Boggy Ck @ Kingscott Lane | C |
| Boggy Ck @ McKinnons Rd | C |

| Band | O/E score | Interpretation |
|---|---|---|
| A | 0.85-1.14 | index value within range of the central 80% of reference sites |
| B | 0.55-0.84 | fewer families than expected, potential mild impact on water or habitat quality |
| C | 0.25-0.54 | many fewer families than expected, moderate to severe impact |

Larger invertebrate species that may be of local interest are listed in Table 16. Experience in other river systems suggests that mussel fauna in both systems may change due to regulation. It is possible that mussel *Velesunio ambiguus*, which is favoured by slow water conditions, may expand its range and move into previously faster-flow main channel sites. This raises the possibility (yet to be confirmed) that it may out-compete the other mussel species adapted to faster water movement (*Alathyria jacksoni* and *Hyridella* spp.).

**Table 16: Decapod crustacean (crays and shrimp) and bivalve mollusc (mussel) species recorded from or thought to be present in the Thomson-Macalister River system.**

| Common Name | Scientific Name |
|---|---|
| **Native Species** | |
| **Crays** | |
| Common Yabby | *Cherax destructor* |
| Central Highlands Burrowing Cray | *Engaeus affinis* |
| Granular Burrowing Cray | *Engaeus cunicularius* |
| Lowland Burrowing Cray | *Engaeus quadrimanus* |
| Gippsland Spiny Cray | *Euastacus kershawi* |
| Central Highlands Spiny Cray | *Euastacus woiwuru* |
| **Shrimp** | |
| Freshwater Shrimp | *Paratya australiensis* |
| **Freshwater Mussels** | |
| Murray River Mussel | *Alathyria jacksoni* |
| Pea Mussel | *Corbicula australis* |
| Coastal Freshwater Mussel | *Hyridella australis* |
| Coastal Freshwater Mussel | *Hyridella depressa* |
| Coastal Freshwater Mussel | *Hyridella drapeta* |
| Southern River Mussel | *Hyridella narracanensis* |
| Slow water Mussel | *Velesunio ambiguus* |

### A3.6 Water Quality

There is insufficient information available with which to compare existing and pre-European water quality conditions. Water quality objectives for selected indicators have been set in SEPP objectives for the Latrobe and Thomson, as have phosphorus load reduction targets for the protection of Lake Wellington (EPA 1996).

Previous assessments of water quality data supplied by the WGCMA and the Victorian Water Quality Monitoring Network (as reported in CRCFE 1999) have identified a longitudinal deterioration in water quality in the lower reaches of the Thomson and Macalister rivers, especially for turbidity, salinity and phosphorus (Figures 21 to 23).

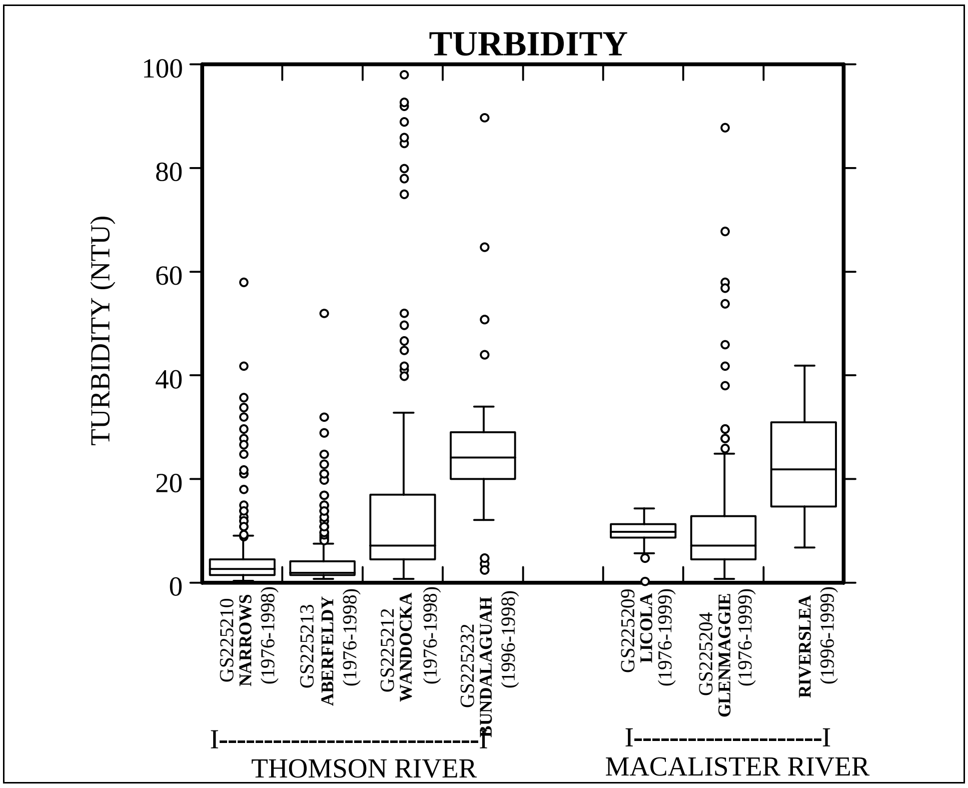



**Figure 21: Box plots of Turbidity in the Thomson and Macalister River systems (Boxes show median, 25%ile, 75%ile, 10%ile and 90%ile, plus outliers)**

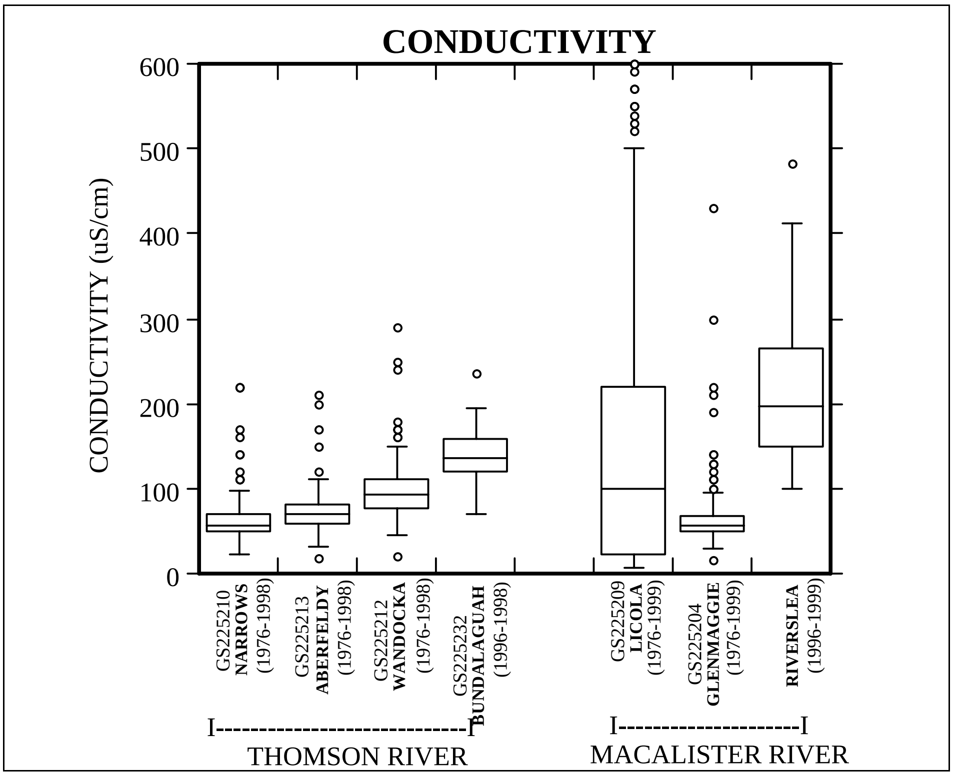



**Figure 22:** **Box plots of EC in the Thomson and Macalister River system (Boxes show median, 25%ile, 75%ile, 10%ile and 90%ile, plus outliers)**

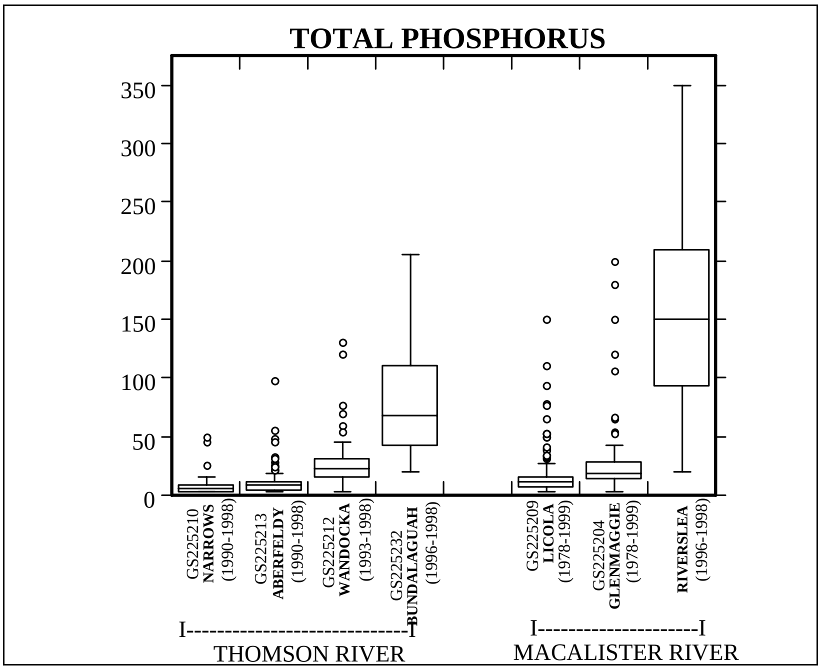



**Figure 23:** **Box plots of TP (µg/L) in the Thomson and Macalister River system (Boxes show median, 25%ile, 75%ile, 10%ile and 90%ile, plus outliers)**

## APPENDIX 4 FLOW EVENT METHOD FOR IDENTIFYING ENVIRONMETNAL FLOWS

The Flow Event Method (FEM):

- Represents the geomorphic and ecological impacts of flow regulation in a meaningful way and is directly linked to the objectives of the restoration plan;
- Provides a defensible approach to assessing environmental flow releases based on best available knowledge;
- Accounts for the natural dynamism in flow-related bio-physical process by using the natural flow regime as a template for the environmental flow regime;
- Can be used in combination with a water allocation model to evaluate and optimise water allocations for environmental and economic gains; and
- Can account for the combined benefits of structural rehabilitation and environmental flow releases.

It is widely accepted that an environmental flow regime has to preserve some of the variability in flows that was present prior to regulation. Using this principle, FEM can be used to identify aspects of the natural variability that are important for maintaining a "healthy" river. This approach is based on an understanding of the key mechanisms by which flow variability influences stream communities. A brief overview of the method, using information related to the Snowy River, is presented below. The method is equally applicable to the Thomson and Macalister Rivers.

To illustrate this method, a time-sequence of daily discharges for the unregulated condition, is shown in the top graph of Figure 24. Three key flow conditions are important for the maintenance of health in this river:

1. Low flow events that lead to exposure of the stream bed (and disturbance of biota), preserve some in-stream habitat as refuge for biota such as fish and invertebrates, or provide 'freshes' to maintain water quality;
2. The medium flows that affect stream geomorphology by altering bar bedform, transporting sediment, providing pool habitat and flow over riffles. Medium flows also enable redistribution of animals from refuges, and improve water quality.
3. High flows that inundate the floodplain and maintain wetland processes.

The occurrence of different flow events can be characterised by looking at frequency and magnitudes, an approach similar to that used to analyse flood frequency. This analysis tells us how frequently flow events of various magnitudes would have occurred in the natural flow regime and how they now vary with river regulation.

Ensuring that an adequate minimum base flow is maintained has been the focus of most environmental flow allocations. Maintaining the base flow is important to ensure that sufficient wetted habitat is maintained at the times of very low flow. Conversely, enhanced flows over the irrigation season, when flows would normally be low, may be detrimental to those species that prefer to spawn during low flow conditions (Humphries *et al*. 1999). For the Thomson and Macalister rivers, low flow requirements have been characterised previously as 130 ML/d or natural (CRCFE 1999).

Pulses of water associated with medium flows are now known to be important cues for fish breeding, fish migration and for other ecological processes, such as flushing stagnant pools in a river and moving nutrients and organic matter downstream (Cullen *et al*., 1996; Harris &

Gehrke, 1997). These flows are also important for re-connecting nearby billabongs and other wetlands with the river channel, and in supplying water to terminal wetlands. Review of flow data for the lower Thomson River suggest that it is the medium sized flow events (up to a 2-year recurrence interval) that have been lost since regulation. Section A3.1 identified 1-year and 2-year floods (medium flows) at Cowwarr Weir as 7800 ML/d and 13,400 ML/d respectively. The 1-year flood is similar to the ‘minor flood’ threshold used by the Bureau of Meteorology, who define minor flooding upstream of Cowwarr Weir and at Wandocka as 7,300 ML/d and 13,200 ML/d respectively. CRCFE (1999) identified small to medium flows for physical habitat functioning as 1,000-8,200 ML/d in the Thomson River at Wandocka and in the Macalister River. Further characterisation of medium sized events is required to ensure that environmental flow releases are targeted to specific ecological objectives.

Larger floods (high flows) are critical for maintaining channel structure, scouring fine sediments and redistributing organic material and sediments downstream and out onto the floodplain. Without these floods, sediment would build up in the river, allowing plants such as willows to colonise and further constrict the channel. These large floods are also important for re-connecting the river to its floodplain, including billabongs and wetlands. Flows that inundate most of the wetlands on the floodplain were identified as 20,000 ML/d upstream of Cowwarr Weir and 19,400 ML/d at Wandocka (Bureau of Meteorology information presented by Gippel *et al*. 1993). Analysis of flows in the Thomson River in this report and previous studies (e.g. CRCFE 1999; Gippel *et al.* 1993) suggest that the large flood events have not been affected by regulation.

The basis of FEM is to provide a flow regime that restores (if possible) the natural frequency of ecologically important flow events. For example, flows in the lower Snowy River have been reduced because of the diversions from the upper catchment and the change in the frequency of bed exposure is shown Figure 24. The frequency of events is indicated by the average recurrence interval for a range of event magnitudes. In this case, the maximum proportion of the bed that is exposed during the low flow event is used as the event magnitude.

FEM sets hydrological targets using the frequency analysis shown in Figure 25. The target is specified by the maximum percentage change in the recurrence interval for any event magnitude. For example, we could set a maximum reduction of 50% in recurrence interval as a target. Without environmental flow releases, the greatest change in event frequency is 75%, shown by the dashed arrow in Figure 25.

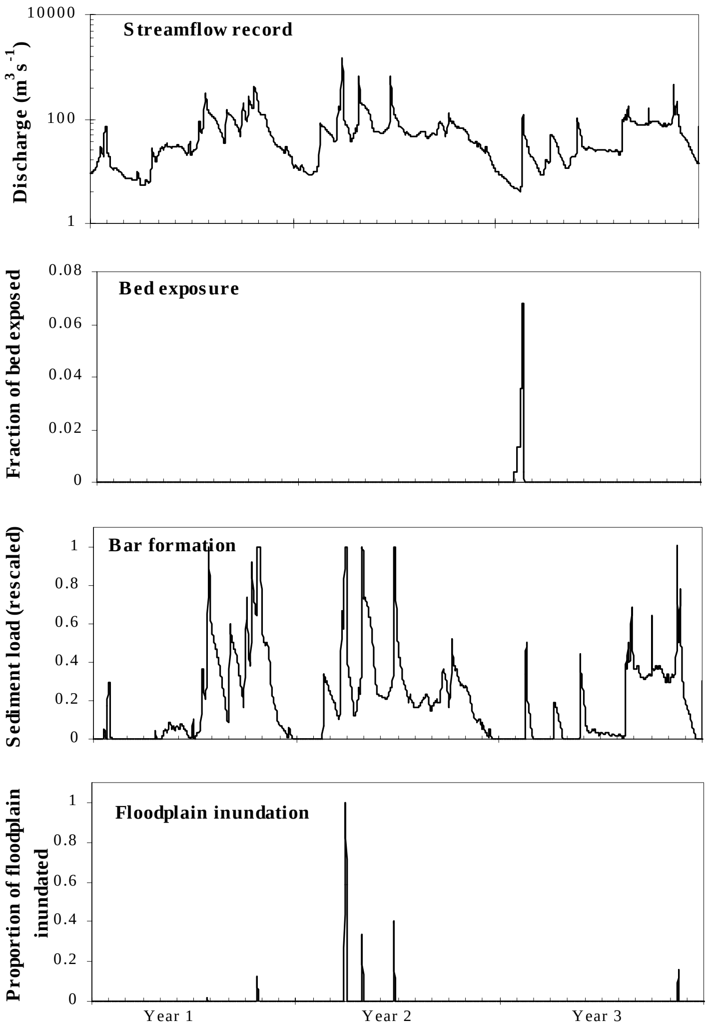



**Figure 24: Streamflow hydrograph for a three year period (top) and the time of three different flow events (i) bed exposure, (ii) alternate bar formation and (iii) floodplain inundation**

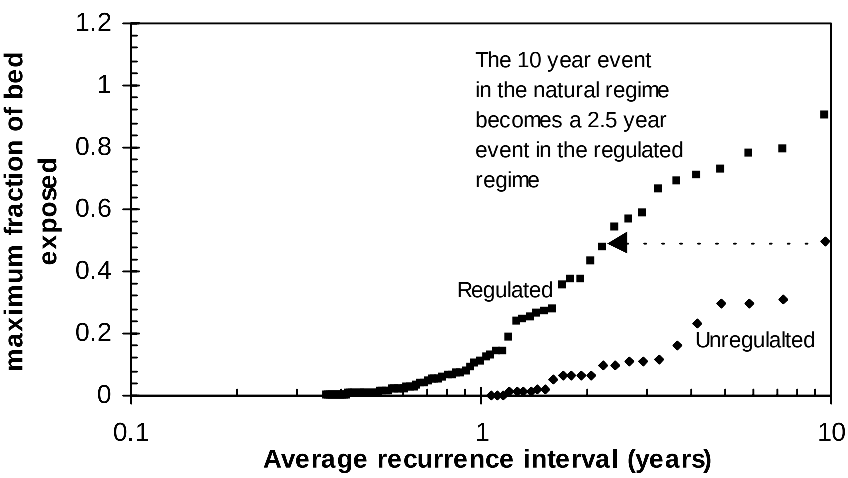



**Figure 25: Average recurrence interval of bed exposure events in the Snowy River, before (diamonds) and after (squares) regulation by the Snowy Mountain Scheme**

## APPENDIX 5 AUSRIVAS MODELLING

The following information is taken from the AUSRIVAS web site (Coysh *et al.*, http://ausrivas.canberra.edu.au/ausrivas). AUSRIVAS predicts the macroinvertebrate fauna expected to occur at a site with specific environmental characteristics, in the absence of anthropogenic stress. The fauna observed (O) at a site can then be compared to fauna expected (E), with the deviation between the two providing an indication of biological condition. The fauna expected at a site may be estimated from 'reference' sites, which have the same environmental characteristics but are known to be minimally disturbed by human impacts. A site displaying no biological impairment should have an O/E ratio close to one, but this will decrease as the macroinvertebrate assemblage and richness are adversely affected, presumably in response to some environmental impact. The predicted taxa list also provides a 'target' invertebrate community to measure the success of any remediation measures taken to rectify identified impacts. In addition to calculating the expected number of taxa at a site, AUSRIVAS also calculates the expected SIGNAL (Stream Invertebrate Grade Number - Average Level) score for a site (Chessman 1995). SIGNAL scores provide a measure of impairment due to organic pollution.

## APPENDIX 6 PERFORMANCE MONITORING PROGRAM DESIGN

A monitoring and evaluation program is essential to ensure that environmental flows and other rehabilitation measures have an effect, and to assess whether that effect is towards some desired condition or target. Common approaches to the design of monitoring or evaluation studies include a Before-After-Control-Impact (BACI) design to identify if environmental flows result in some change (whether 'good' or 'bad') to the riverine environment, or the comparison of *test* sites (presumably impaired) with *reference* sites (usually in excellent condition or an otherwise desirable state) to evaluate whether changes (if any) are towards some desired target condition.

BACI is a widely-used form of monitoring design, developed for assessing ecological changes resulting from some human activity (e.g. environmental impact) in comparison with sites at which no activity has taken place. It is desirable that the experimental and control sites be as similar as possible in every aspect, except the 'impact'. Implicit in the BACI design is an appropriate period of measurement prior to the introduction of environmental flows. To test the impact of environmental flows in the Thomson and Macalister rivers, therefore, the ideal control would be a similar river that also had a large dam, but which did not receive environmental flows. Our ability to apply a BACI approach will therefore depend on the availability of suitable 'control' rivers against which we can measure changes in the Thomson and Macalister Rivers. Unfortunately locating lowland control rivers is usually very difficult. BACI designs are often expensive when applied to large systems, are rigid in nature and do not readily lend themselves to assessing the effects of multiple actions.

Monitoring designs may be based on the comparison of features at impacted *test* sites with those of *reference* sites presumed to be in good condition. In this case, reference rivers are those that are similar to the Thomson and Macalister rivers in terms of geomorphology and other environmental conditions, but which may not be regulated. The hypothesis to be tested would be of the form: "The difference between Thomson River and the reference river (e.g. for some feature such as fish or macroinvertebrate community) is smaller *after* the introduction of environmental flows than it was *prior* to their introduction." The approach of using a reference system, rather than controls, is not quite the same as a BACI experiment, as the rivers being used for comparison are likely to be different from the Thomson before the environmental flows are released.

The temporal and spatial scales of disturbance and recovery are important considerations for a monitoring and evaluation program. For example, macroinvertebrate communities may recover from disturbance over a period of months, while changes to riparian vegetation and river geomorphology may take many years to become apparent. Changes in water quality may occur at scales ranging from hours to years. The effect of in-stream barriers may be evident over considerable distances. Given the large variability between rivers in the region, multiple controls (i.e. multiple rivers) will be required to detect changes in the Thomson and Macalister rivers in response to environmental flows if a BACI experiment was the sole basis for a future monitoring program. The use of multiple control sites is likely to be logistically difficult and expensive. Therefore, an approach based on whether the system has moved closer to a target (reference) condition is recommended. This approach will not have the power to detect whether change results from any individual action (which may be difficult in any event due to confounding factors associated with ongoing catchment activities etc.) but will indicate whether the system is improving or not. This approach will be strengthened by the collection of ‘before’ data in addition to data collected after rehabilitation actions have commenced.

Opportunities for defining reference conditions for a number of river attributes exist within the study area (e.g. Thomson River at Wandocka for macroinvertebrates, lower reach of the Thomson River for in-stream habitat such as snags and riparian and wetland vegetation, and possibly native fish populations).

**What to Measure**
Ensuring that future actions meet the objects identified in Chapter 6 will require monitoring of river flows, fish communities, riparian and wetland macrophyte communities, in-stream habitat (including snags) and water quality. The monitoring program should be adaptable to the needs of the investigations recommended in this report. There is the potential to develop considerable synergistic links between the components of the monitoring program and the proposed investigations.

***Flow monitoring***
Flow monitoring needs were identified by CRCFE (1999). These included continuous monitoring stations at Wandocka and Bundalaguah on the Thomson River. Also, flows should be monitored at two points on the Macalister River, above and below Maffra Weir. The Flows Working Group is currently undertaking evaluation of water losses and the suitability of the Bundalaguah gauge.

***Fish***
The key features of fish assemblages that will provide an indication of the efficacy of environmental releases are:

- *Species composition* – the diversity of species, and whether species are being lost or gained by the rivers as a result of remedial actions.
- *Size and age distribution and annual recruitment* – the contribution of different age and size classes to the populations and thus whether the population is relying on younger or older fish to maintain numbers and whether recruitment is occurring every year or in only a subset of years.
- *Abundance of native/introduced species* – whether the flow conditions are better for desirable or undesirable species.
- *Growth* – whether there are sufficient quantities of the right types of food to allow the rivers to support strong healthy fish.
- *Seasonal migrations* – determines whether fish are responding to environmental cues, such as flow to move upstream or downstream to spawn and whether fishways are indeed allowing this large scale movement.

Monitoring of fish assemblages should be conducted twice annually, although more frequent sampling would provide more detailed understanding of migrations and growth. Sampling sites (100 to 150 m length) should be replicated within the different reaches in each river, using electrofishing from a boat in deeper waters and a backpack or bank-mounted device in shallow water. Additional trapping using fyke nets would collect those species not satisfactorily collected by electrofishing (e.g. Bass in larger pools).

Monitoring of fish passage will be required at all sites with fish passage problems/fishways, including sampling below, within and above fishways. This will require sites in the Macalister River above and below Lake Glenmaggie, and above and below Maffra Weir. Sites will also be required above and below Cowwarr Weir on the Old Thomson and Rainbow Creek, and at reference sites in the lower Aberfeldy River. Sampling should occur during mid-spring to early summer, concentrating on fish abundance, composition and size. The employment of two-way fish traps will also be useful to determine in which direction the fish are migrating.

***Riparian and Wetland***

The community structure of riparian vegetation is best measured along permanent transects to consider:

- Floristics - species composition with a high proportion of natives;
- Structure - groundcover, understorey and overstorey each well developed;
- Measures of intactness, invasion of weeds, index of regeneration and species composition can also be measured in a similar fashion to that of the Index of Stream Condition adopted in Victoria (White and Ladson 1999).

Aquatic and riparian plants have the potential to reflect the biotic affects of environmental flows directly, albeit on the medium to long term. Permanent transects should be established in each reach and extending from the upper floodplain (say the extent of a one-in-ten year flood) to lower bank. The transects should be positioned in 'fenced-off' areas where possible to avoid disturbance by livestock. Ideally the transects should be surveyed and fixed sampling points identified, as the main purpose is to track changes over time (CRCFE 1999).

Timing of sampling is complicated by the fact that flow change will effect different plant species in different ways – e.g. seed dispersal, germination, the success of competitors – which might be best measured at different times of the year. Reid and Brooks (1988) examine this problem in detail and suggest a biennial sampling program as the best compromise. For a long-term program such as envisaged for the Thomson-Macalister one annual sampling might be sufficient, recognising that not all plant responses will be detected in this way. Some work is required to decide on the best sampling time, but mid-late November (after initial growth but before senescence in some annual species) may be appropriate.

Similar monitoring transects should be established in billabongs along the lower reaches of the Thomson and Macalister Rivers immediately upstream and downstream of the confluence with the Macalister.

***In-stream Habitat***

*Habitat mapping*

A series of representative sub-reaches should be established in the Thomson and Macalister Rivers and detailed habitat mapping undertaken in each. Mapping should be undertaken at yearly intervals and the methods employed by Maddock and Bird (1996) are recommended. These are quick, easy to undertake and provide information on the location and composition of physical habitats, such as snags, at a site.

*Monitoring of large-scale river channel change*

Lateral instability has been a feature of both the Thomson and Macalister Rivers in the past. This has the potential to significantly influence both the quantity and quality of in-channel habitat. There are a number of potential avulsion sites, as outlined in Erskine *et al*., (1990) that should be monitored. Hence, aerial photography and field surveys should be used to

monitor lateral movements in both river systems. This should occur at five year intervals or after major flood events.
Cross section and longitudinal surveys of the channel should also be carried out along Rainbow Creek at 5-year intervals and after major floods to monitor changes in channel geometry.

***Water Quality***

*Physico-chemical water quality*

Some water quality monitoring is being undertaken in the study rivers as part of the Victorian water quality monitoring network. In particular, samples are taken monthly at three sites in the Thomson (Aberfeldy 225213; Narrows 225210; Wandocka 225212) and two sites in the Macalister (Licola 225209; Glenmaggie 225204). Additional water quality samples are being taken at Bundalaguah in the Thomson and at Riverslea in the Macalister. It is recommended that water quality sampling continue at these sites, with the focus on Wandocka, Riverslea and Bundalaguah. The most important flow-related water quality indicators are turbidity, EC and nutrients (total phosphorus, filterable reactive phosphorus, total nitrogen, nitrate and ammonia) and organic carbon (total and dissolved).

*Biological Measures of River Health*

Macroinvertebrates are widely used in monitoring programs of Australian rivers because they respond in a relatively short time frame (compared to geomorphology and large fish species, for example), and because they include a diverse array of animals with preferences for a range of environmental conditions.

The 1996 SEPP for the Latrobe and Thomson Rivers recognises the protection of aquatic ecosystems, but does not specify biological objectives. Waters of Victoria (WoV), the umbrella SEPP for surface waters, is currently being reviewed and rewritten. It is proposed that the new WoV has nutrient and biological (macroinvertebrate) objectives for the protection of freshwater aquatic ecosystems.

As part of this process, macroinvertebrate assemblages at reference condition sites (sites assumed to be closer pristine or otherwise desirable condition) across the State have been used to define five biological regions based on patterns of community assemblage. Environmental factors were used to assist with the positioning and the general description of the biological regions (Newall and Wells 2000; Wells *et al*. Submitted). Objectives have been defined for each region in order to maintain the quality of sites in good condition (including reference sites) and to set targets or goals for improving the condition of sites in a degraded condition. The lower Latrobe and Thomson rivers fall within one region, B4, which is characterised by coastal plains in the south and inland plains and low foothills in the north and east. It is acknowledged that this region has been greatly altered by human activity and that reference streams will be further from their natural state when compared to reference sites in some other regions.

Five biological indicators of river condition have been chosen, falling into three basic groups:

- A measure of diversity (number of invertebrate families);
- Biotic indices (SIGNAL and Ephemeroptera, Plectoptera and Trichoptera (EPT) indices);
- Measures of community structure (number of key families and AUSRIVAS predictive models).

Numerical objectives for each indicator were derived from the distribution of scores for each indicator from the reference sites within each region, similar to the AUSRIVAS modelling (Appendix 5). The biological objectives are set at family level (Table 17), sampled using rapid biological assessment methods and from samples collected from two seasons (spring and autumn) within one year.

One set of objectives has been developed to cover region B4. As the objectives and regionalisation where developed at a state level, more specific objectives using the same indicators can be developed for the Thomson and Macalister rivers. The EPA has developed similar objectives for both the Yarra and Western Port catchments as part of SEPP reviews.

**Table 17: Biological objectives for region 4**

| Indicators | # of Families score | SIGNAL index score | Key families combined habitat score | AUSRIVAS | |
|---|---|---|---|---|---|
| Region & habitat | | | | O/E score | Band |
| Region 4 Riffle | 23 | 5.5 | 22 | 0.82 | A |
| Region 4 Edge | 26 | 5.5 | | 0.85 | A |

NB EPT index score does not apply to Region 4

A one-off survey to compare current conditions to pre-Thomson Dam data collected during previous surveys by Malipatil and Blyth (1982) and Marchant *et al.*, (1984) will also help to refine objectives.

## APPENDIX 7 LANDCARE GROUP VISION STATEMENTS

### *Newry-Macalister Landcare Group*
### *Ten Year Plan*

***10 Year Picture of the Future***

In 2009, the Newry-Macalister Landcare Group will be a success/inspirational if we have achieved the following:

1. Cleaner waterways (9 votes)
2. Bellbird corner is a showcase (8votes)
3. Replacing willows with native trees on streams (6 votes)
4. Link existing vegetation (5 votes)
5. More trees – native vegetation (including understorey (3 votes)
6. Foxes, rabbits etc eradicated (2 votes)
7. Carp – minimised (2 votes)
8. Control of weeds (1 vote)
9. Off stream watering points (1 vote)
10. An aware community, including farmers (0 votes)
11. This group co-operates with other groups (0 votes)

***Hurdles***

Hurdles that may prevent us achieving our picture of the future for 2009, include:

1. At the moment there is no known way to eradicate/deal with carp **(we are concerned about this – we cannot influence)**
2. Small part of a bigger picture **(we can influence this / find a way to overcome)**
3. Bellbird corner is not seen as a priority by people/authorities outside of this group **(we are not sure if we can influence this, or if we are simply concerned about this hurdle)**
4. Too much perseverance required to get action – Bellbird Corner **(we can influence this / find a way to overcome)**
5. Some farmers do not think linking vegetation is a good idea **(we can influence this)**
6. Getting seeds is difficult – seasonal **(we can influence this / find a way to overcome)**
7. Fencing costs money **(we can influence this / find a way to overcome)**
8. Cost of new watering systems **(we are not sure if we can influence this, or if we are simply concerned about this hurdle)**
9. We do not have a detailed overall plan **(we can influence this / find a way to overcome)**
10. We set too many unrealistic tasks **(we can influence this / find a way to overcome)**
11. Trees are not seen as a productive part of the farm **(we can influence this / find a way to overcome)**
12. Don’t have current funding for Bellbird Corner, eg bridge **(we can influence this / find a way to overcome)**
13. There is run-off into waterways **(as individuals, we can change our practices on our own farms)**
14. On our own we can only do so much **(we can influence this / find a way to overcome)**
15. We are speaking for 100 landholders **(we are concerned about this – we cannot influence)**

***Goals (3 year):***

The following are pathways / directions to achieve our picture for the future in 2009 and take into consideration the hurdles listed above:

1. To have some achievable short-term goals (mini goals or stepping stones)
2. To increase our membership
3. Have an agreed to, realistic plan
4. To revegetate with local species
5. Develop an action plan to achieve cleaner water (including all problems – then prioritise into measurable stages)
6. Bell Bird Corner is managed for the community / recreation – it is picturesque is a model
7. Landcare assists us as individual farmers to revegetate and to control weeds & vermin.

Goals 5, 6 & 7 were seen as the priority for action planning.

## *Macalister Thomson Landcare Group*
## *Ten Year Plan*

### *10 Year Picture of the Future*

In 2010, the Macalister Thomson Landcare Group will be a success/inspirational if we have achieved the following:

12. Well sheltered farms with shade, shelter & tree corridors (11 votes)
13. Weed and Vermin free farms (6 votes)
14. Productive farms (5 votes)
15. Lower the watertable to alleviate salinity (3 votes)
16. Community working together (0 votes)
17. Beautiful entrance to the Macalister Research Farm (2 votes)
18. Roadside plantations leading into Landcare group area (1 vote)
19. Ongoing involvement/education of school children (2 votes)

Note: The number of votes represents the priorities of the Macalister Thomson Landcare Group.

### *Hurdles*

Hurdles that may prevent us achieving our picture of the future for 2010, include:

1. Dry conditions **(we are concerned about this – we cannot influence)**
2. Other priorities calling on our time **we are not sure if we can influence this, or if we are simply concerned about this hurdle)**
3. Skill to plant native trees to ensure their survival/effectiveness **(we can influence this / find a way to overcome)**
4. Knowledge about native trees **(we can influence this / find a way to overcome)**
5. Ongoing maintenance (trees & encroaching weeds) **(we are not sure if we can influence this, or if we are simply concerned about this hurdle)**
6. Fencing type (eg. power to electric fence erratic) **(we can influence this / find a way to overcome)**
7. Neighbours who aren't participating in control (vermin/weeds) programs **(we can influence this / find a way to overcome)**

### *Big Picture Goals:*

The following are pathways / directions to achieve our picture for the future in 2010 and take into consideration the hurdles listed above.

- Well Sheltered – Shade & Trees
- 
- Develop individual farm plans
- Put individual farm plans into a larger area plan (piece-meal)
- Other labour brought in
- Hire of equipment for fencing
- Educate people as to what trees they should plant

***Weed free/ Vermin free - District/Farms***

- Lead by example
- Aim to get everyone involved
- Promote what you're doing
- Incentive for involvement
- Enforcement (DNRE) as a last resort
- Vermin control programs continuing

***Productive Farms***

- As per previous goals
- Individuals tap into other programs eg. Target 10, Wellington Salinity Group etc.
- Salinity Control with trees and keeping informed (via tapping into Wellington Salinity Group.

## *Macalister Landcare Group*

## *Ten Year Plan*

### *10 Year Picture of the Future*

In 2009, the Macalister Landcare Group will be a success/inspirational if we have achieved the following:

20. Pleasant environment to live in; 'Clean & Green' (6 votes)
21. Enlarged Landcare Group: socially, economically & environmentally active (5 votes)
22. Won't see weeds, feral animals or erosion: Will see before & after pictures (5 votes)
23. A ten year plan (4 votes)
24. Clean rivers, with native trees not willows (2 votes)
25. Community that is stable or expanding - landholdings not going backwards (1 vote)
26. Community enjoying what they have achieved (1 vote)
27. More native / indigenous vegetation, including restored grasslands (0 votes)
28. Well informed & politically active community (0 votes)

Note: The number of votes represents the priorities of the Macalister Landcare Group.

### *Hurdles*

Hurdles that may prevent us achieving our picture of the future for 2009, include:

8. Apathy to seeing benefit of being 'clean & green'
9. People see themselves only in terms of their farm, not as part of a bigger community
10. Farms are farmed by 'non-owners'
11. Some areas owned by older generation, and are unable to undertake works
12. Sheer size of works / projects eg erosion works
13. Clash with diversity of interest groups eg motorbikes etc
14. Old ideas – not current Landcare thinking / profit driven
15. Very little recognition / incentive for works
16. Apprehension to security of ongoing funding in the long term

***Big Picture Goals:***

The following are pathways / directions to achieve our picture for the future in 2009 and take into consideration the hurdles listed above.

***Pleasant environment to live in: 'Clean & Green'***

- Education:
  - To appreciate what we have & how we can improve the environment.
  - What has been done / is being done
  - To show the financial benefit of Landcare
  - The Landcare group is ordinary people
  - Target:
    - Sharefarmers / owners
    - Older generation
    - General community: get everyone involved, united community in our resolve
- Involve local business people
- Aim for local eradication of feral animals & weeds
- Creation of corridors – locally co-ordinated
- Protection of existing 'grassy woodlands' (remnant vegetation)

<u>*Enlarged Landcare Group: socially, economically & environmentally active:*</u>

- Incentives for involvement / action
- Recognition for work done
- Make Landcare enjoyable
- Cover all age groups
- Channel other interest groups, ie finding common ground eg fly fishing clubs, motorbike clubs
- Planning for meetings, ie meetings are well planned
- Showing that Landcare is environmentally, socially & economically beneficial

<u>*Won't see weeds, feral animals or erosion: Will see before & after pictures*</u>

***A scenic drive of highlights & areas under change***

- Recording: photographically & written our achievements / before & afters
- Prioritise weeds for action. Create an action plan for weeds.
- Create an action plan to control feral animals.
- Identify and map erosion sites. Develop an action plan for erosion sites.
- Co-ordinate with other authorities

## *Glenmaggie-Seaton Catchment Group*
## *Five Year Plan*

### *5 Year Picture of the Future*

In 2005, the Glenmaggie-Seaton Catchment Group will be a success/inspirational if we have achieved the following:

1. The whole community is involved in the Glenmaggie-Seaton Catchment Group (7 votes)
2. Erosion stopped & no evidence of erosion, lots more trees and minimal run off (7 votes)
3. Map the treated areas and use satellite technology (5 votes)
4. Roadside plan – litter, roadside vegetation, signs, table drains & Roadsides are included as corridors, roadsides are in pristine condition (4 votes)
5. Glenmaggie, Back Creek and other creeks in the area are looked after (eg Boxthorns controlled) (3 votes)
6. Aware of various uses of tree plantations, some commercial value trees as well as other trees and the right trees planted and knowledge of the right trees to plan. (1 vote)
7. Highlighted improved water quality as a result of works in upper catchment of Lakes (1 vote)
8. Proposals are a success (0 votes)
9. Before photos (0 votes)

Note: The number of votes represents the priorities of the Glenmaggie-Seaton Catchment Group.

### *Helping/Hindering*

Things that may hinder us achieving our picture of the future for 2005, include:
1. Bad seasons
2. Finances
3. Negative attitudes by various individuals

Things that are helping us achieve our picture of the future for 2005 include:
1. Co-operation of NRE and CMA
2. Enthusiasm of group members
3. Local tree nursery
4. Co-operation and help between members
5. Financial assistance (more flexible now than some years ago)

## APPENDIX 8 RESOURCES REQUIRED FOR INVESTIGATIVE WORKS

**Table 18: Proposed investigative works for the continued development of a rehabilitation plan for each river (Note that costs are indicative only)**

| Works | Person Months | Timeframe | Priority | Resources |
|---|---|---|---|---|
| • Model natural versus current daily flow to allow detailed assessment of future environmental flow scenarios for the Thomson River, Rainbow Creek and Macalister River | 1 Month | 1 Month | High | $8,000 |
| • Use the FEM as a tool for defining future environmental flows, including alternative release strategies from Thomson Dam; | 1 Months | 3 Months | Medium | $50,000 |
| • Conduct native fish survey to confirm the extent of degradation and to quantify rehabilitation targets (species and abundance) | 3 Months | 6 Months | High | $80,000 |
| • Investigate aspects of the flow regime important for spawning and migration for coastal native fish species | 12 months | -3 Years | Medium** | > $200,000 |
| • Check efficiency of existing fishway on the Old Thomson | 0.5 Month | 6 Months | High | $45,000 |
| • Investigation species/habitat relationships for native coastal fish species | 24 Months | 2-3 Years | Medium** | > $200,000 |
| • Reanalyse existing data sets to assess invertebrate status and quantify rehabilitation targets | 2 Months | 2 Months | Low | $10,000 |
| • Survey aquatic vegetation in the main channels, review flow and habitat requirements, quantify rehabilitation targets | 12 Months | 1 Year | Medium | $60,000 |
| • Investigate the interaction between flow and the size and shape of the river channel | 18 Months | 2-3 years | High | $200,000 |
| • Relate changes to channel shape and habitat diversity to river biota | 2 Months | 6 Months | Medium | $30,000 |
| • Identify the crucial flows required to sustain keystone riparian vegetation communities or species (e.g. river redgum) | 1 Months | 3 Months | High | $20,000 |
| • Identify options for providing crucial flows if required (e.g. piggy back on Aberfeldy flows in the Thomson River) | 0.5 Months | 3Months | High | $20,000 |
| • Conduct a survey to identify remnant wetlands and their condition, identify flood levels and flows required for wetting. Use collected information to quantify rehabilitation targets. | 3 Months | 6 Months | High | $40,000 |
| • Identify levees and those that should be removed to ensure overbank flows reach key wetlands | 0.5 Months | 1 Month | High | $10,000 |
| • Undertake flow split trials to gauge the response of native fish to changes in the flow split between Rainbow Creek and the Old Thomson | 12 Months | 1-2 years | High | $100,000 |
| • Design fish passage past Cowwarr Weir | 2 Months | 6 Months | Medium | $30,000 |
| • Investigate the extent of cold water releases from Lake Glenmaggie | 0.5 Months | 6 Months | High | $8,000 |
| • Undertake analysis of existing flow data for the Macalister River to confirm changes to river hydrology since regulation | 0.5 Month | 1 Month | High | $4,000 |
| • Evaluate translucent dam releases from Lake Glenmaggie | 12 Months | 1 Year | High | $100,000 |
| • Design fish passage past Maffra Weir | 2 Months | 6 Months | High | $20,000 |
| • Design fish passage past Lake Glenmaggie | 2 Months | 6 Months | Low | $50,000 |

** Investigations will provide very important information but are given medium priority due to high cost and potentially very long time scale for gaining result