SINCLAIR KNIGHT MERZ
SKM

NORTH EAST CATCHMENT MANAGEMENT AUTHORITY

Upper Ovens River Environmental FLOWS Assessment

ISSUES PAPER

- Final
- 28 September 2006

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Sinclair Knight Merz
ABN 37 001 024 095
590 Orrong Road, Armadale 3143
PO Box 2500
Malvern VIC 3144 Australia
Tel: +61 3 9248 3100
Fax: +61 3 9248 3400
Web: www.skmconsulting.com

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Steering Committee	
Matthew O'Connell	North East Catchment Management Authority
Grant Jones	Victorian Environment Protection Authority
Tony Long	Department of Sustainability and Environment
Daniel Lovell	Goulburn-Murray Water
Les Ryan	North East Region Water Authority
Aleksy Bogusiak	North East Region Water Authority
Joy Sloan	Department of Primary Industries (Fisheries)
Greg Stevens	Department of Sustainability and Environment
Steve Nicol	Department of Sustainability and Environment
Community Contacts	
Cameron Alexander	Alpine Shire
Jamie Baker	Goulburn-Murray Water
Alan Barlee	Upper Ovens Landcare Group
Fred Bienvenu	Mt Buffalo Field Naturalists
Helen Collins	Environment Victoria
Sid Dalbosco	Ovens Water Services Committee
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Graham Hughes	Rostrevor Hop Gardens
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Ruth Lawrence	La Trobe University
Colin McCormack	Tobacco and Associated Farmers Co-operative
Kerry Murphy	Tobacco and Associated Farmers Co-operative
Alf Richardson	Water Services Committee - Ovens
Lynette Robertson	VFF – Ovens Valley
Terry Wisener	North East Water
Greg Wood	Wangaratta Fly Fishing Club

Glossary of terms and abbreviations

AUSRIVAS	Australian River Grade and Assessment System.
Anastomosing	A channel that splits into several channels that rejoin regularly.
Autotrophic	Do not rely on outside sources to supply organic food. Autotrophic systems are dominated by photosynthesising organisms
Biofilm	An organic matrix comprised of microscopic algae, bacteria and microrganisms that grow on stable surfaces (e.g. logs, rocks or large vascular plants) in water bodies.
Catchment	The area of land drained by a river and its tributaries.
Current flow series	Series of streamflows which represent the current level of development.
Compliance point	Gauging station at which flows are measured to ensure compliance with recommendations.
Debouching	Emerge into larger body or area.
Dissolved oxygen (DO)	Concentration of oxygen in the water column. A measure of the amount of oxygen available to aquatic flora and fauna.
DSE	Department of Sustainability and Environment.
EFTP	Environmental Flows Technical Panel.
Environmental flow	River flows (or periods of drying) allocated for the maintenance of aquatic and riparian ecosystem, measured in megalitres per day (ML/d).
Ephemeral stream	A waterway containing water only after unpredictable rain.
Floodplain	Temporarily inundated lateral river flats, usually of lowland rivers.
FSR	Flow Stressed Ranking.
North East CMA	North East Catchment Management Authority
Geomorphology	The study of the physical form of, and processes operating in, rivers. It aims to provide an understanding of the physical processes governing the current state of a river.
G-MW	Goulburn-Murray Water.
Groundwater	Water occurring below the ground surface.
Habitat	The place or environment in which a plant or animal usually lives; the subset of physical and chemical environmental variables that allow an organism to survive and persist.
Heterotrophic	Obtain organic food from the environment. Heterotrophic streams are not dominated by photosynthesising organisms.
Hydrology	The study of the surface and subsurface water. Sometimes used loosely to describe the water regime.
Instream	Of, or occurring within the wetted area of a running water body.
ISC	Index of Stream Condition. Presents an indication of the extent of change in respect of five key 'stream health' indices: hydrology, physical form, streamside zone, water quality and aquatic life.
Lowland waterway	A stream section at low altitude, that is sinuous and often with width to depth ratios greater than 20.
LWD	Large Woody Debris. Branches and trees that have fallen in the river channel. Often referred to as snags.
Macroinvertebrates	Aquatic invertebrates that are large enough to be retained by a 500 µm net or sieve. Includes insects, crustacean, aquatic worms, and aquatic

	snails.
Macrophytes	The term is used to describe water plants other than microscopic algae; they may be floating or rooted.
Mean	Average. Equally far from two extremes.
Median	The middle value in an ordered sequence of values.
Megalitre (ML)	One million litres (an Olympic size swimming pool is about two megalitres).
Natural flow series	Modelled flow series that reflects what current flows would be without consumptive use. It is not meant to reflect historical flows prior to catchment development.
Nutrients	Natural elements (usually phosphorus and nitrogen) that are essential for plant and animal growth.
Percentile exceedence flows	The flow which is exceeded for the defined percentage of time. E.g. the 80th percentile flow is exceeded 80% of the time and is therefore a low flow. Also commonly used: 20th and 50th percentile where 20th percentile exceedence flow is a relatively high flow and the 50th percentile exceedence flow may also be called the median flow.
pH	Level of acidity in a range from 0-14: low pH (values <7) refers to high acidity and high pH (values >7) refers to low acidity.
Piedmont	The foot of a mountain. Used to describe the gentle slope leading down from the steep mountain to the plains.
Pool	A stream section where there is no discernable flow and usually deep.
Reach	A length of stream that is reasonably uniform with respect to geomorphology, flow and ecology.
Recruitment	The addition of new members into a population through reproduction or immigration.
Regulated catchment/river	A river or creek where the flow of the river is controlled through the operation of large dams or weirs to meet water use demands downstream.
Riffle	A stream section with fast and turbulent flow over a pebble bed with protruding rocks. Characterised by a broken water surface.
Riparian	Vegetation found along the banks of streams and rivers.
Riparian zone	Any land which adjoins, directly influences, or is influenced by a body of water.
Run	A stream section with low to moderate laminar flow with unbroken water surface.
SEPP	State Environment Protection Policy.
SIGNAL	Stream Invertebrate Grade Number Average Level.
SFMP	Stream Flow Management Plan.
Spawning	Production and deposition of eggs; related to fish reproduction.
SKM	Sinclair Knight Merz.
Snag	Branches and trees that have fallen in the river channel; also called Large Woody Debris (LWD).
Substrate	The base, or material, on the bed of the river.
Taxa	Any defined unit in the classification of living organisms (i.e. species, genus, family).
Thalweg	The long profile of a river valley; term used to describe the line that joins

	the lowest points along the entire length of the streambed.
Threatened	A generic term used to describe taxa that are rare, vulnerable, endangered or insufficiently known and are subject to a threatening process.
Transect	Line drawn across a stream channel and perpendicular to the direction of flow for standardising measurements of width, depth velocity discharge etc.
Tributary	A river or creek that flows into a larger river.
Turbidity	The cloudy appearance of water due to suspended material (sediment).
Unregulated catchment/river	A river system where no major dams or weir structures have been built to assist in the supply, or extraction of water.
Upland	A stream section at high altitudes with a river channel often less than 10 times the channel depth.
Water-dependent	Aquatic species or those dependent on river water for survival.
Weed	Any plant that has, or has the potential to have, a negative impact on a valuable natural resource and that requires some form of action to reduce that impact.
VRHS	Victorian River Health Strategy.
VWQMN	Victorian Water Quality Monitoring Network.

1. Introduction

The Upper Ovens River is one of 21 unregulated catchments identified in the Victorian State Government White Paper “Our Water Our Future” (DSE 2004b), as a priority for the development of a Stream Flow Management Plan (SFMP). SFMPs aim to share available water resources between all stakeholders in unregulated catchments in a balanced and sustainable manner that is in line with the Murray-Darling Basin CAP agreement. The SFMP emphasises water sharing arrangements between consumptive users and the environment during periods of stress, such as summer low flow periods. Stakeholders in the Upper Ovens River catchment include, but are not limited to the environment, licensed diverters and non-consumptive uses (e.g. recreation and aesthetics).

An environmental flow assessment is required to inform the development of the SFMP and Northern Victorian Sustainable Water Strategy. The previous environmental flow assessment for the Upper Ovens River (SKM 2001a) focussed on the availability of fish habitat under different flow conditions and made recommendations for minimum flow requirements rather than a complete environmental flow regime. This previous study was conducted before the FLOWS method (DNRE 2002) was developed and a Technical Audit Panel review of that work recommended future assessments should focus on a wider range of ecosystem components and use the FLOWS method to develop recommendations for all components of the flow regime (Stewardson and Quinn 2003). The FLOWS method has been adopted for all environmental flows studies in Victoria since 2002 and therefore environmental flow determinations for the Upper Ovens River will be comparable to other systems throughout the state. This updated assessment will use daily flow series for natural and the current flows in the Upper Ovens River and provide an explicit link between environmental values, environmental objectives and environmental flow recommendations.

1.1 Objectives

This environmental flows assessment will determine environmental flow requirements for the upper Ovens River and its tributaries including, Barwidgee Creek, Buckland River, Buffalo Creek, Happy Valley Creek and Morses Creek. Specifically this study will:

- identify the water dependent environmental and social values;
- gauge the current health of the identified environmental values;
- assess the current and future threats to the identified environmental values;
- recommend environmental flow objectives based on the environmental values of the river;
- recommend an environmental flow regime to meet the flow objectives;
- analyse the frequency of times the recommended flow regime is met under current and proposed flows and determine the shortfalls of achieving those flows; and
- assess risks to the environmental values if the recommended flow regime is not met.

The overall objective of this report is to identify the flow dependant assets of the upper Ovens River, document their current condition and articulate specific objectives for each asset that if achieved would result in an ecologically healthy river.

1.2 Approach

The FLOWS method is based on the concept that key components of the natural flow regime influence various biological, geomorphological and physicochemical processes in rivers and streams. Key flow components are likely to vary between river systems, but every stream system has some key flow components that are essential to maintain an ecologically healthy and functioning aquatic ecosystem. In the FLOWS method, an environmental flows technical panel (EFTP) identify specific environmental values and threats for the waterway and then determine the key flow components that are required to maintain, rehabilitate or restore those values and reduce threats.

The major stages of the FLOWS method are shown in Figure 1-1. The method involves the collection of information through desktop studies, field assessments and stakeholder consultation. In the first stage of the process, literature reviews and a catchment inspection are used to divide the study area into reaches based on natural hydrology, geomorphology, water management (e.g. location of regulators) and the distribution of key biota and select representative sites within each reach. The outcomes of this first stage are presented in a *Site Paper*. In the second stage, the technical panel visit each of the representative sites to select channel cross section survey locations, identify key physical and biological attributes and consider key flow components that are likely to affect the condition of these attributes.

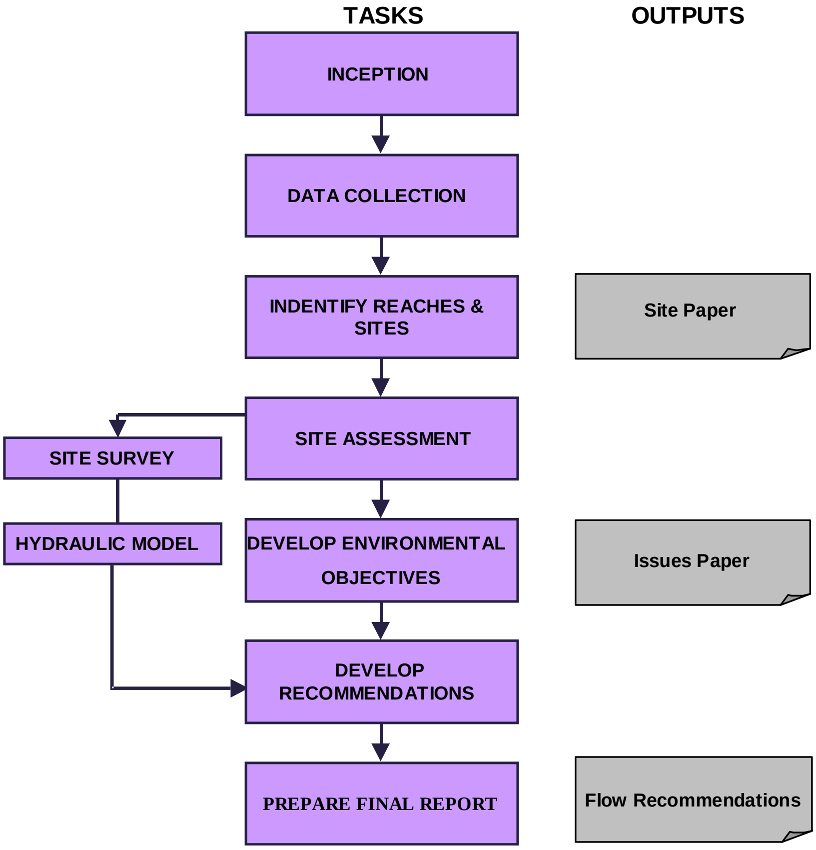

Figure 1-1: Outline of the steps involved in the FLOWS method.

Information from the site assessment and an extensive literature review are used to identify key assets, values and threats throughout the study area and to determine key environmental objectives for each reach. The outcomes of this second stage are presented in the *Issues Paper*. Selected cross sections at each site are surveyed and this information is used to build a hydraulic model that helps identify specific discharges associated with particular flow components. The final stage of the process involves a workshop where the technical panel run flow scenarios through the hydraulic model to develop environmental flow recommendations to meet the agreed environmental objectives for the system. The final flow recommendations are presented in the *Final Report*.

The EFTP consists of members with expertise in specific environmental disciplines. The EFTP members for the Upper Ovens Flows study, and their relevant discipline, are listed below:

- Dr Bruce Abernethy — Geomorphology
- Dr Jane Roberts — Instream and riparian vegetation
- Dr Andrew Sharpe — Macroinvertebrates and water quality
- Dr Simon Treadwell — Fish and ecological processes
- Kristen Sih & Robert Morden — Hydrology

1.2.1 Development of environmental flow objectives

Environmental flow objectives set the direction and target for the environmental water recommendations and are clear statements of what outcomes should be achieved in providing environmental flows. The process of setting environmental objectives involves first identifying the environmental assets, setting environmental objectives against these, and then identifying the flow required to meet the environmental objectives. Environmental objectives are developed for those ecological assets that have a clear dependence on some aspect of the flow regime, including:

- individual species and communities;
- habitats; and
- ecological (physical and biological) processes.

Objectives are typically developed such that, if met, the flow could sustain an ecologically healthy river as defined by the Victorian River Health Strategy (VRHS) . The objective of the Victorian River Health Strategy is to:

Achieve healthy rivers, streams and floodplains which meet the environmental, economic, recreational and cultural needs of current and future generations.

The North East Regional River Health Strategy (RRHS) (North East CMA 2005) sits under the VRHS, but has its own vision that emphasises the communities' sense of belonging to and need to manage rivers in their local area. The RRHS vision is:

Our rivers are managed to support ecological health whilst meeting our social and economic needs.

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 dominate 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 the river's length;
- native fish and other fauna can move and migrate up and down the river;
- linkages between the river and floodplain and associated wetlands are able to maintain ecological processes;
- natural linkages with the sea are maintained; and
- associated estuaries are productive ecosystems.

This does not mean that a river must be pristine to be ecologically healthy. It recognises that there can been some change from the natural state but not to the point that there is a major loss of natural features, biodiversity or function.

Environmental flow objectives are primarily aimed at protecting and/or improving the condition of native plant and animal communities and natural physical processes. Flow objectives will not be set for exotic animals such as trout and will not be set to maintain water resources for urban and agricultural use. Some social, recreational and economic values such as fishing, rafting/kayaking and other forms of tourism may or may not benefit from improved flow regimes, but specific flow objectives are not set for these activities.

Ultimately objectives must be developed for assets that have a clear dependence on some aspect of the flow regime, they need to provide a clear statement of what outcomes are expected (i.e. be meaningful and measurable) and that if met, mean that the flow could sustain an ecologically healthy river. Following the FLOWS method the direction of a particular objective is expressed as one of three main targets:

1) maintain – keep the condition of the resource in it's current state;
2) rehabilitate – move the condition of the resource to some improved state other than natural (usually less than natural); and
3) restore – move the condition of the resource back to natural conditions.

The *maintain* objective is applicable where the current condition indicates a species, community or process is in a sustainable condition and not subject to current or future threats.

The *rehabilitate* objective is applicable where there has been a decline in the condition of a threatened species or community, or where there are active threatening processes that require management intervention to prevent further degradation. A rehabilitate objective specifies the end point of the rehabilitation, either ecologically healthy, or some modified end point that represents an improvement over current conditions.

The *restore* objective is applicable where there is scope to improve the condition of a particular species or community to a level that would have occurred without the current levels of impact. The restore objective is not often applied in environmental flows studies because the development within the affected catchment is often too great to support a return to natural or pre-development conditions.

In order to determine if management actions have been successful in achieving environmental objectives for particular species or communities a specific monitoring and evaluation program linked to defined targets is required. As a general rule, the target for rehabilitation can be measured as an increase in the adult survival, rate of recruitment of key species characteristic of that community, or an expansion in distribution of a species to areas where an appropriate flow has been returned. However, it is important to understand that even if the flow components necessary to support an environmental objective are met, there may be other, non-flow factors that limit the achievement of environmental objectives (e.g. poor water quality, riparian and floodplain degradation or presence of exotic species). Where appropriate we have provided objectives for complementary waterway works that help address some of these limiting factors in order to maximise the potential for achieving flow related objectives.

1.3 Community consultation

A panel of community contacts (Table 1-1) has been established to provide a forum for which the key stakeholders of the upper Ovens River can input to the study by:

- providing local knowledge;
- providing local opinions about values and threats to the river;
- assisting with the selection of reaches and sites;
- reviewing environmental objectives;
- participating in community meetings;
- assisting in the development of flow objectives; and
- reviewing draft flow recommendations.

Table 1-1: Community contacts.

Panel Member	Affiliation
Cameron Alexander	Alpine Shire
Jamie Baker	Goulburn-Murray Water
Alan Barlee	Upper Ovens Landcare Group
Fred Bienvenu	Mt Buffalo Field Naturalists
Helen Collins	Environment Victoria
Sid Dalbosco	Ovens Water Services Committee
Bernie Evans	VR Fish North East
Leanne Guy	Outdoor recreation
Graham Hughes	Rostrevor Hop Gardens
Geza Kovacs	Rio's Ripple Rafting
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Alf Richardson	Water Services Committee - Ovens
Lynette Robertson	VFF – Ovens Valley
Terry Wisener	North East Water
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To date, the community contacts have met on three occasions. The first meeting on 9 May 2006 was to provide the group with an overview of the FLOWS process and to present the draft *Site Paper*. Feedback was sought on the preliminary assessment of environmental values and threats to the upper Ovens River system and on the selection of flow assessment reaches and study sites. One of the major outcomes of the first meeting was the need to determine separate environmental flow requirements for Morses Creek. The Morses Creek sub-catchment is now included as a separate reach for this environmental flow study. The second community meeting was undertaken during the EFTP field assessment on 23 May 2006. This meeting was held at Apex Park near Myrtleford and provided the community contacts with an opportunity to meet the EFTP members, observe the field component of the FLOWS process and ask questions of individual EFTP members. The third meeting, held on 12 July at the Best Western High Country Motor Inn in Bright, presented the draft *Issues Paper.*

Some of the issues raised at these three meetings relate to recreational, social or economic values and assets that are not being addressed in this environmental flows assessment. These issues are summarised in Appendix A, but they fall outside the general environmental considerations for this FLOWS assessment and as a result will not be considered in setting environmental flow objectives.

1.4 Report objectives and structure

This *Issues Paper* is the second output from the Upper Ovens River flows study and primarily aims to identify key ecological values and set clear environmental objectives for the upper Ovens River system. This report reviews available information to determine key ecological values within the upper Ovens River system, discusses their current condition, assesses threats to these values including flow related impacts and identifies ecological objectives that environmental flow recommendations will aim to address.

Following this introduction, Section 2 provides background information on the upper Ovens River catchment; in particular it describes the study area and selected reaches and field assessment sites. Section 3 describes the hydrology of the system as well as impacts and modification to the flow regime. Sections 4-8 outline and discuss key environmental assets and issues, particularly relating to water management, within the study area. Section 9 consolidates all of the information presented in the previous sections and articulates specific environmental objectives for environmental values within each reach. Section 10 outlines how the information contained in this report will be used in subsequent steps of this project.

2. Background

The Ovens River rises on Mt Hotham to drain a catchment area of 1580 km^2 at its confluence with the Buffalo River at Myrtleford (Figure 2-1, overleaf). In its uppermost reaches, the Ovens River is comprised of two fast flowing mountain streams (the East and West Branches). At the township of Harrietville, the East and West Branches join to flow through a narrow floodplain only a few hundred metres across. Major tributaries of the upper Ovens River are the Buckland River, Barwidgee, Buffalo, Morses and Happy Valley Creeks. Morses Creek joins the Ovens River at Bright, the Buckland River joins at Porepunkah and Buffalo Creek joins upstream of the Myrtleford stream gauge. Happy Valley Creek and Barwidgee Creek enter the river in a small section downstream of the stream gauge at Myrtleford. There are many smaller tributaries throughout the catchment and a number of these have rural and stock and domestic demands.

The majority of the upper catchment is steep, hilly country, with extensive native forest and moderate development of pine plantations. The lower catchment has a lower gradient and a wider floodplain that is dominated by agriculture (particularly tobacco, grape and orchard crops). Rainfall is highest in the upper reaches of the catchment and there is high runoff, particularly associated with spring snowmelt. Flow is highly variable, but the highest flows generally occur in August and the lowest in March (SKM 2001a). There is a strong interaction with groundwater, with recharge occurring mainly in winter and spring. Groundwater inflows decrease through summer and autumn as the groundwater table level drops, and generally cease by early to mid autumn (RWC 1988).

While the system is unregulated (with no major storages), farm dams and direct pumping from the Ovens River and its tributaries are used to harvest water for crop irrigation, domestic stock use and town supply. Demand for water is highest during summer when crop demand is at its peak. In times of drought, supply is very limited in the upper Ovens River and in some of its tributaries (G-MW 2003).

Townships throughout the Upper Ovens River valley such as Harrietville, Bright, Porepunkah and Myrtleford also draw their water supply from the system. All of these areas are developing and populations in these townships are projected to increase over the next 20 years, which will increase the demand for potable water. Tourism is a major industry in the catchment and high visitor numbers during summer and the ski season can substantially increase urban water demand. The summer tourism peak coincides with the high irrigation demand and their combined effect can substantially affect streamflow in years with low rainfall.

The *Upper Ovens River Water Resources Study* (RWC 1988) suggested that the river is over committed, particularly during summer. Extractions during summer can extend the natural low flow period, which may reduce the depth of pools and decrease the concentration of dissolved oxygen which is vital for the survival of fish and other biota over summer. Winter and spring flows are relatively unaffected by water resource development and help maintain existing environmental values in the system. The natural seasonal flow pattern for high flows in winter and spring and lower flows in summer and autumn is retained under current flow conditions (G-MW 2003).

SKM (2001a) undertook an environmental flow assessment for the Upper Ovens River as part of the previous SFMP process. The assessment only recommended summer environmental flow requirements as these are of most concern in unregulated catchments. However, the study did acknowledge that other flow components were important in maintaining natural river processes. Recommendations were based on a review of environmental values and threats, current and historical hydrology, and the results of a rapid field assessment of fish habitat requirements at three sites. Six recommendations were made and linked to proposed environmental management objectives. These recommendations are summarised in Table 2-1.

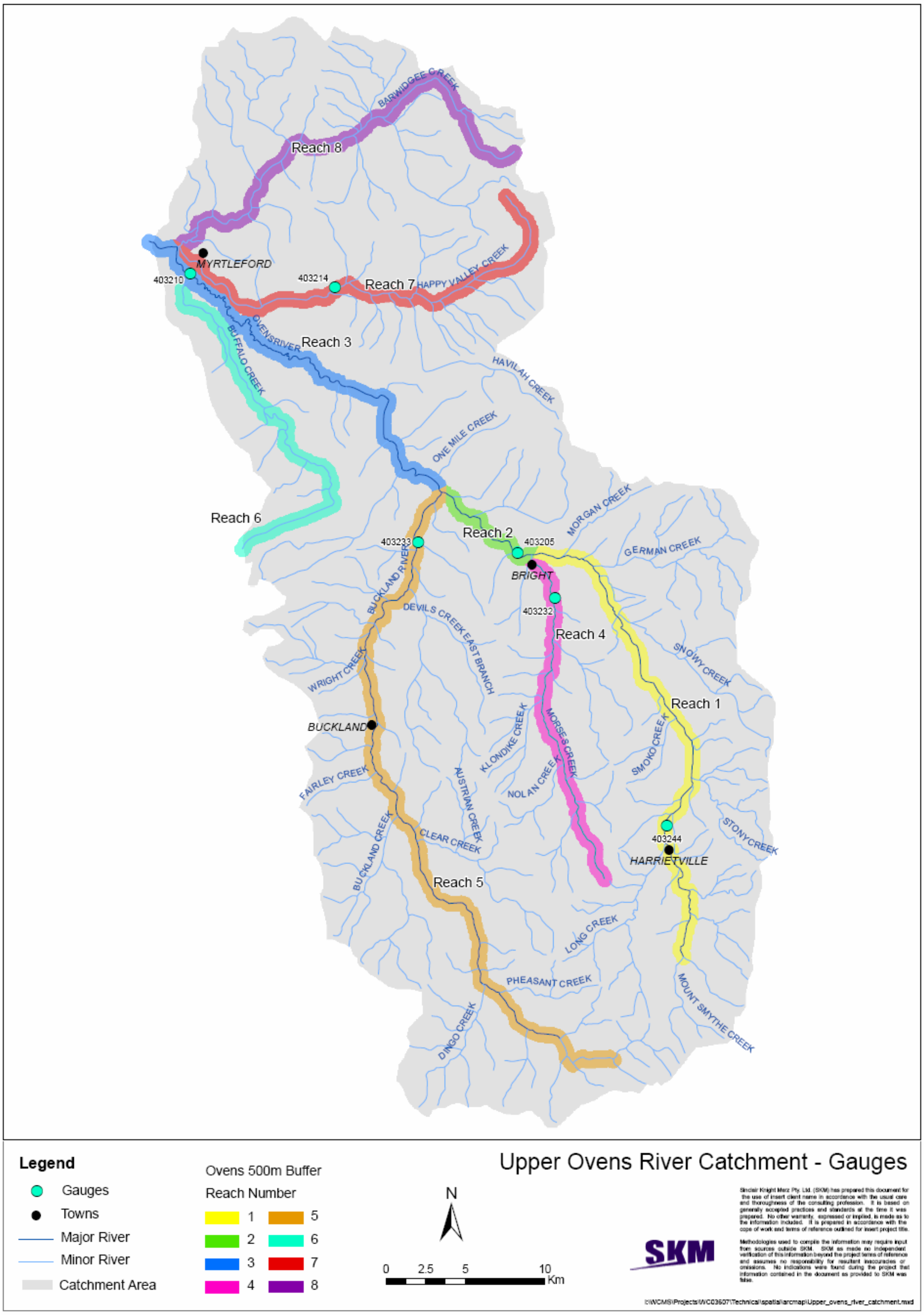
- **Table 2-1: Summary of recommendations from the 2001 environmental flows assessment for the upper Ovens River (SKM 2001a).**

No.	Recommendation
1	**No diversions from the Ovens River or tributaries below:** ▪ 70 ML/day in the Ovens River at Bright; ▪ 200 ML/day in the Ovens River at the gauge at Myrtleford (restriction up to the Bright gauge); ▪ 60 ML/day at the gauge on the Buckland River; ▪ 10 ML/day at the gauge on Barwidgee Creek
2	**Reporting of compliance be on a 5 day average flow**
3	**During the first 5 days of restrictions, flow be temporarily allowed to fall to:** ▪ 60 ML/day in the Ovens River at the gauge at Bright; ▪ 170 ML/day in the Ovens River at the gauge at Myrtleford; ▪ 50 ML/day at the gauge on the Buckland River; ▪ 9 ML/day at the gauge on Barwidgee Creek; even if natural flows are above this. After 5 days, flows should be the same as natural.
4	**No new on-stream storages should be constructed**
5	**Fish passage be ensured at all identified barriers**
6	**Shading native vegetation be retained. If a willow removal program is implemented, care should be taken to ensure that shading in summer is maintained.**

The Ovens River downstream of the confluence with the Buffalo River is regulated by Lake Buffalo (capacity 24,000 ML) and Lake William Hovel (capacity 13,500 ML), which are used to supply irrigation, stock and domestic and urban consumption demands. Flow in the Upper Ovens River and in the regulated section have the potential to influence assets in the Heritage Reach of the Ovens River between Killawarra and Lake Mulwala (North East CMA 2005).

2.1 Project study area

This project will determine environmental flow requirements for the Ovens River upstream of the Buffalo River and major tributaries including Barwidgee Creek, Buckland River, Buffalo Creek, Happy Valley Creek and Morses Creek (Figure 2-1). The initial project brief indicated that Morses Creek should be included in the assessment for the Ovens River upstream of Bright. However, in response to input received at the project community contacts meeting on 9 May 2006, it was decided that the assets and diversion issues associated with Morses Creek warranted a separate assessment for this tributary.



- **Figure 2-1: Upper Ovens River environmental flows study area.**

2.2 Overview of values and assets in the upper Ovens River catchment

The North East Regional Catchment Strategy (North East CMA 2004) identified wetlands, groundwater, rivers and streams and their associated aquatic and terrestrial ecosystems as key inland water assets for the region and the upper Ovens River. The Ovens River between Killawarra and Lake Mulwala is the only Victorian lowland river that is listed as a heritage river for its environmental values. The upper Ovens River has excellent water quality and diverse aquatic communities that are integral to maintaining the condition and quality of the heritage reach. The upper Ovens River also supports populations of endangered fish such as the trout cod that has been relocated to the area.

Water extraction from the upper Ovens River and its tributaries supports valuable agricultural crops such as grapes, tobacco, apples, hops and chestnuts. Many tourists visit the upper Ovens River to explore the natural environment, participate in adventure activities, fish for trout and sample the region's food and wine.

The social, environmental and economic values of the rivers, streams and wetlands in the three management units that cover the main waterways in the upper Ovens River study area are summarised in Table 2-2.

Table 2-2: Identified values and threats to waterways in the upper Ovens River identified in the North East Regional River Health Strategy (North East CMA 2005).

Values and Threats	Middle Ovens Tributaries including Buffalo Creek, Barwidgee Creek and Happy Valley Creek	Upper Ovens River from lower alpine slopes to Myrtleford	Upper Ovens Tributaries including Morses Creek and Buckland River
Values			
Environmental	Significant flora: Monaro Peppermint (*Eucalyptus radiate ssp.. Robertsonii*) Soft Ledge-grass (*Poa hothamensis var. parviflora*)		Significant flora: Buffalo Sallee (*Eucalyptus mitchelliana*) Omeo Gum (*Eucalyptus neglecta)*
	Numerous endangered State-wide EVC's	Numerous endanged state-wide EVC's	Numerous endangered state-wide EVC's
	Significant fauna: Murray Spiny Cray (*Euastacus armatus*) Mountain Galaxias (*Galaxias olidus*) Spotted Tree Frog (*Litoria spenceri*) (*E) Trout Cod (*Maccullochella macquariensis*) (*E)	Significant fauna: Grey Goshawk (*Accipiter novaehollandiae*) Mountain Galaxias (*Galaxias olidus*)	Significant fauna: Mountain Galaxias (*Galaxias olidus*) Smoky Mouse (*Pseudomys fumeus*) (*E) Woodland Blind Snake (*Ramphotyphlops proximus*)
		Identified in VRHS as an Icon River Contains examples of rare wetland types including: Freshwater Meadows Shallow Freshwater Marshes	
Social	Nil	Swimming, fishing and camping particularly near Bright, Porepunkah and Harrietville.	Swimming and fishing Passive recreation particularly on Morses Creek near Wandiligong and Bright

Values and Threats	Middle Ovens Tributaries including Buffalo Creek, Barwidgee Creek and Happy Valley Creek	Upper Ovens River from lower alpine slopes to Myrtleford	Upper Ovens Tributaries including Morses Creek and Buckland River
Economic	Water for irrigation	Water for irrigation	Water for irrigation
	Part of a proclaimed water supply catchment	Proclaimed water supply catchment	Part of a proclaimed water supply catchment
		Tourism in Bright and surrounding areas	Tourism in Bright and surrounding areas
Threats	Channel deepening in some waterways including Barwidgee Creek	Bed and bank instability and highly modified channel – predominantly due to historical gold dredging	Bank and bed instability on Morses Creek and Buckland River due to historic gold dredging
	Loss of instream habitat due to channelisation	Loss of instream habitats due to sediment infilling	
	Limited fish migration to floodplain wetlands	Little wetland connectivity due to agricultural pursuits	Little wetland connectivity due to agricultural pursuits
	Degraded water quality due to agricultural pursuits and land clearing	Degraded water quality – exacerbated by erosion after 2003 bushfires	Degraded water quality – exacerbated by erosion after 2003 bushfires
	Exotic flora – especially willows	Exotic flora – especially willows, which are becoming the predominant form of vegetation.	Exotic flora – especially willows, which are becoming the predominant form of vegetation.
	Stock access and cultivation impacts to riparian zone		Cultivation and stock access exacerbate the ongoing degradation of native vegetation
		Fish barrier at Porepunkah Weir	
Overall value	No reaches with High Community Value or high Ecological Health in this management unit.	All reaches in this management unit have High Community Value	No reaches with High Community Value or high Ecological Health in this management unit.

2.3 Study reaches and field assessment sites

For the purpose of providing environmental flow recommendations, we have divided the upper Ovens River system into eight reaches (Table 2-3 and Figure 2-1). Reaches were determined based on points of regulation (e.g. major dams, weirs and offtakes), major tributary inflows, changes in landform, geology, channel and floodplain morphology and changes in ecological processes or communities. Information detailing physical and ecological patterns along the Ovens River and its major tributaries upstream of Myrtleford and justification of this reach selection is provided in the *Site Paper* (SKM 2006a).

The EFTP selected one representative site within each reach for detailed flow assessment (Table 2-3). Selected sites contain examples of the major geomorphological and ecological features that typify that reach. Sites were assessed by the EFTP between May 22-24 2006, and channel survey data collected for use in a hydraulic model that will assist in developing flow recommendations.

Table 2-3: Upper Ovens River reaches and field assessment sites.

Reach		Site location	Easting/Northing
1	Ovens River upstream of Morses Creek	Ovens River 3 km downstream of Harrietville gauge	506446 / 5920022
2	Ovens River: Morses Creek to Buckland River	Ovens River at Bright gauge	495855 / 5935434
3	Ovens River: Buckland River to Buffalo River	Ovens River at Apex Park Myrtleford	474455 / 5953060
4	Morses Creek catchment	Morses Creek upstream of gauge	498266 / 5932227
5	Buckland River catchment	Buckland River 1.5km upstream of Harris Lane	4891181 / 5934938
6	Buffalo Creek catchment	Buffalo Creek at Clemens Lane	474300 / 5951800
7	Happy Valley Creek catchment	Happy Valley Creek at Carrolls Rd gauge	483863 / 5951923
8	Barwidgee Creek catchment	Barwidgee Creek 1.5km downstream of Kirk's Bridge.	478706 / 5957129

3. Hydrology

3.1 Background

In the upper most reaches, the Ovens River exists as two typical fast flowing mountain streams (the East and West Ovens River branches), which meet at the township of Harrietville. Four major tributaries join the Ovens River above the Buffalo River. Morses Creek joins the Ovens River at Bright and the Buckland River joins at Porepunkah. Happy Valley Creek and Barwidgee Creek enter the river in a small section downstream of the stream gauge at Myrtleford.

Typical of catchments in northern Victoria, flows in the upper Ovens River are highly variable, with extreme low flows occurring more frequently than higher in the catchment (SKM 2001a, G-MW 2003). Rainfall is highest in the upper reaches of the catchment and there is a high degree of runoff, particularly with the snowmelt in spring (G-MW 2003). During wet years, flows at Myrtleford are approximately 2.6 times higher than those recorded at either Bright, or the largest tributary, the Buckland River (SKM 2001b).

Discharge in the upper Ovens River and its tributaries are measured or have been measured at nine gauging stations (Table 3-1). Rainfall and water levels are also measured on the Ovens River at Eurobin and on the Buckland River at Twelve Mile, but flow is not currently measured in Buffalo Creek and Barwidgee Creek (Table 3-1). Data from all stream gauging stations in the upper Ovens River catchment show seasonal flow patterns, with flows typically highest in August and lowest in March (SKM 2001a). At Myrtleford, the March median daily flow is 154 ML/d and the August median daily flow is 2,911 ML/d. At Bright, the March median daily flow is 48 ML/d and the August median daily flow is 1,062 ML/d. On the Buckland River at Harris Lane, the March median daily flow is 50 ML/d and the August median daily flow is 1,148 ML/d. Flow at Barwidgee Creek is lowest during March, with a median daily flow of 12 ML/d, but peak flows (median 171 ML/d) at this site occur in September (SKM 2001b).

Low flow can occur over extended periods during the summer months (SKM 2001b). For example, flows below 3 ML/d have been recorded at Myrtleford in all months from December to April (G-MW 2003). This has the potential to impact on water quality in the river, fish migration and instream habitat. Extended low flows also affect the amount of water available for irrigators.

■ **Table 3-1: Active Victorian Water Quantity Monitoring Network flow gauging stations throughout the study area .**

VWQMN Gauging Station	Location	Comment
403244	Ovens River at Harrietville	
403210	Ovens River at Myrtleford	
403205	Ovens River at Bright	
403233	Buckland River at Harris Lane	
403216	Buffalo Creek at Myrtleford	Records ceased in 1982
403214	Happy Valley Creek at Rosewhite	
403211	Happy Valley Creek at Myrtleford	Records ceased in 1948
403236	Barwidgee Creek at Myrtleford	Records ceased in 1989
403232	Morses Creek at Wandiligong	
403250	Ovens River at Eurobin	Water level only
403253	Buckland River at Twelve Mile	Water level only

3.2 Groundwater

The geological units in the Upper Ovens catchment are dominated by Devonian/Ordovician bedrock and alluvial sediments as shown in Table 3-2. The bedrock consists of Devonian granite which forms Mount Buffalo and consolidated Ordovician sediments comprise the surrounding ranges. These consolidated sediments have been incised by alluvial processes, creating deep, narrow sided valleys in which unconsolidated alluvial sediments have been deposited. The alluvial deposits in the Upper Ovens catchment consist of Tertiary sediments in the Calivil Formation, Shepparton Formation and Coonambidgal Formation.

■ **Table 3-2 Summary of Upper Ovens catchment geology (Duell 2005).**

Age	Formation	Description	Thickness
Quaternary	Coonambidgal Formation	Ranging between clay and gravel deposited on alluvial flats as channel fill deposits (4)	
	Shepparton Formation	Fine to coarse sand and gravel deposited in a shoestring form because of continuously shifting rivers on the flood plain	<100m
	Calivil Formation	Coarse sand and gravels	
Tertiary	Older Volcanics	Olivine Basalt	100m
Devonian	Granite	Granite and granodiorite	>2km
Ordovician	Gneiss and schists	Metamorphosed sediments (sandstone, shale, siltstone)	>2km

Groundwater is present in both the bedrock and the alluvial sediments in the Upper Ovens catchment. An extensive aquifer system exists in the bedrock, with groundwater contained in cracks in the Ordovician shales and sandstones. This aquifer is used for minor irrigation and domestic purposes near Myrtleford (Tickell and Humphrys 1987), however yields are low in comparison to the alluvial sediments (DNRE 1998).

A complex system of interconnected aquifers operates within the unconsolidated alluvial sediments. The Calivil Formation consists of poorly sorted sands and gravels and has a high transmissivity, high hydraulic conductivity, moderate to high yields (Tickell and Humphrys 1987) and low salinity (Tickell 1977). The Calivil Formation is confined (or semi-confined) and is primarily used for irrigation, minor industrial and urban demands. The Shepparton Formation is a complex network of aquifers that consists of silty clay with some hydraulically interconnected sand beds. The sand aquifers within the Shepparton Formation are typically up to 20m thick, semi-confined (unconfined at very shallow levels, near the surface) and have highly variable hydraulic parameters. Low yields and low hydraulic conductivity were reported by the RWC (1988). Shallow groundwater (generally less than 25m deep) from Shepparton Formation is extracted for irrigation, water table control, stock and domestic purposes (Tickell and Humphrys 1987). The Coonambidgal Formation consists of clays, sands and gravels and has relatively low yields and hydraulic conductivity (Shugg 1987). Most of the groundwater used in the Upper Ovens Valley is taken from aquifers in the Shepparton and Coonambidgal Formations (Tickell 1977) because they have good water quality at relatively shallow depths (SKM 2005).

Recharge to the bedrock aquifer occurs predominantly via rain and is estimated at between 10 and 50mm/year (Tickell and Humphrys 1987). Discharge from the bedrock aquifer predominantly occurs via seeps and springs. Aquifers in the unconsolidated alluvial sediments are recharged via rainfall (10-150 mm/year) (Shugg 1987), irrigation channel seepage (75 – 110 mm/year) (Tickell and Humphrys 1987) and spill from elevated bedrock, terraces and colluvial deposits (Shugg 1987). Discharge from alluvial aquifers occurs through evapotranspiration, seepage to the Ovens River, vertical movement to underlying aquifers (Tickell and Humphrys 1987), down valley flow and extraction bores (SKM 2005).

Overall groundwater movement in the Upper Ovens River Valley is towards the Ovens River (Tickell and Humphrys 1987), but dredged areas of alluvium produce local flow anomalies (Shugg 1987). Because of probable aquifer interconnectivity Goulburn Murray Water has placed a moratorium on any further development of groundwater bores. Groundwater gradients are high at top of valley and low in the base of the valley (close to that of surface water) (Shugg 1987), loosely following topographical gradients.

3.2.1 Impact of groundwater extraction on stream flow in the Upper Ovens River

The Upper Ovens River is predominantly a gaining stream, where groundwater provides base flow to the river, however the river can recharge the groundwater during very high flow events and during drought conditions when groundwater levels fall (Holland *et al.* 2005). Groundwater is extracted to irrigate crops throughout the catchment and these extractions are known to significantly reduce streamflow in the Upper Ovens River and its tributaries during summer low flow periods (Cox 1990, SKM 2005).

Dragline holes and bore pumps are used to extract groundwater throughout the Upper Ovens River valley, but most groundwater extraction occurs along the Ovens River floodplain between Bright and Myrtleford (Table 3-3). Groundwater extractions for irrigation are not metered and therefore the total volume extracted from aquifers is not known, but extraction licences allow up to 6,675 ML/year to be taken. Irrigators that hold groundwater and surface water licences generally use groundwater as a back-up supply only in dry periods, while irrigators that solely use groundwater are estimated to use approximately 45% of their annual allocation in years with average rainfall (SKM 2006b). In dry years, demand on groundwater reserves is much higher combined surface/groundwater licence holders relying on groundwater for up to 70% of their total water allocation and groundwater licence holders using closer to 60% of their full allocation (SKM 2006b).

- **Table 3-3 Total groundwater licence allocation volumes**

Sub-area	Total Licence Volume Allocation (ML/yr)
Ovens River between Harrietville and Bright	241.0
Ovens River between Bright and Myrtleford	4,817.3
Morses Creek	99.0
Buckland River	168.0
Buffalo Creek	242.0
Happy Valley Creek	667.8
Barwidgee Creek	640.8
Total	6,675.9

Poor understanding of the lag time between groundwater extraction and its subsequent effect on streamflow has contributed to uncertainty in quantifying the impact of groundwater extraction during critical low flow periods. Recent modelling has shown that lag times increase with distance from the stream, particularly over the first 300 m from the stream (Holland *et al.* 2005) and it has been suggested that converting some surface water licences to groundwater extraction licences at bores some distance from the stream may shift the impact of water harvesting on streamflow away from the critically low flow period (Holland *et al.* 2005). This type of substitution would only be suitable for relatively short low flow periods as increased groundwater extraction will only delay or could even exacerbate stream flow impacts in extended dry periods or during droughts (Holland *et al.* 2005).

3.3 Water management

Stream flow in upper Ovens River catchment is unregulated, but water is diverted for a range of purposes including crop irrigation, domestic and stock use and urban extraction. Diversion licenses are issued under section 51 of the Water Act 1989 and allow people to take and use water from waterways. Licence entitlements in the upper Ovens River catchment total 8,575 ML/year and include all-year and winter-fill licences. An all-year licence allows the holder to take and use water at any time of year, but is generally used in the summer/autumn period. A winter-fill license only allows the holder to extract river water between July 1 and 31 October, but this water can be stored (e.g. in a farm dam) for use at other times. Winter-fill licences represent less than 10% of all licences, which means that the majority of water is extracted during the summer/autumn period (*Pers. Comm.* Jamie Baker G-MW diversion inspector).

3.3.1 Bulk Entitlement

Four urban bulk entitlement conversion orders allow the North East Regional Water Authority (NERWA) to harvest water from the upper Ovens River catchment to supply the Bright, Myrtleford, Porepunkah and Harrietville townships. The bulk entitlements define the amount of water that an authority is entitled to take and use from a waterway. Bulk entitlements may prescribe the rate and location at which water may be taken and the reliability of the entitlement (Table 3-4).

- **Table 3-4: Summary of North East Water Regional Water Authority's bulk entitlements from the upper Ovens River (G-MW 2003).**

Town	BE volume (ML)	Additional volume by annual transfer from other towns, entitlement holders or licence holders (ML)	Source	Minimum Passing flow (ML/d)
Harrietville	91	74	Simmonds Creek	0.5
			Ovens – East Branch	20% of flows up to 3.0
Bright	704	366	Ovens River	Nil if < 2.0 then sliding up to flow of 39.5 when 9.5 can be taken
			Bakers Gully	0.25
Porepunkah	166	54	Buckland River	50% of flow less than 2.6
Myrtleford	1212 *		Buffalo Creek	4.5
Total	**2173**			
* The Myrtleford BE conversion order allows up to 2,424 ML to be taken over two consecutive years with a maximum of 1,470 ML taken in any one year.				

Bulk entitlement rules impose greater restrictions on extraction rates in dry years and dictate where water is allowed to be extracted to ensure minimum passing flows in source streams. The flow sharing arrangements for each of the four bulk entitlement conversions in the Upper Ovens River are summarised in Table 3-5.

- **Table 3-5: Summary of flow sharing arrangements under Bulk Entitlement Conversion orders in the Upper Ovens River.**

BE Conversion Order	Source Stream	Flow condition	Allowable diversion (ML/d)
Harrietville	Simmonds Creek	Flow in Simmonds Creek < 0.5 ML/d	None
		0.5 ML/d < Flow in Simmonds Creek < 4.8 ML/d	Flow in Simmonds Creek – 0.5 ML/d
		Flow in Simmonds Creek > 4.8 ML/d	4.3 ML/d
	Ovens River East Branch	Flow in Ovens River East Branch < 3.0 ML/d	0.8 * Flow in Ovens River East Branch
		Flow in Ovens River East Branch > 3.0 ML/d	2.4 ML/d
Bright	Ovens River	2.0 < Flow in Ovens River ≤ 3.6 ML/d	2.0 ML/d
		3.6 < Flow in Ovens River ≤ 39.5 ML/d	(2.0 + 0.2*(Flow in Ovens River – 3.6)) ML/d
		Flow in Ovens River ≥ 39.5 ML/d	9.5 ML/d
	Bakers Gully	Flow in Bakers Gully Ck ≤ 0.25 ML/d	0 ML/d
		0.25 < Flow in Bakers Gully Ck ≤ 5.25 ML/d	(Flow in Bakers Gully Ck) – 0.25 ML/d
		Flow in Bakers Gully Ck > 5.25 ML/d	5.0 ML/d
Porepunkah	Buckland River	Flow in Buckland River > 2.6 ML/d	1.3 ML/d
		Flow in Buckland River < 2.6 ML/d	0.5 * Flow in Buckland River
Myrtleford	Ovens River	Flow in Ovens River ≤ 4.5 ML/d	None
		4.5 < Flow in Ovens River ≤ 15.5 ML/d	0.5*(Flow in Ovens River -4.5)
		3.6 < Flow in Ovens River ≤ 39.5 ML/d	(2.0 + 0.2*(Flow in Ovens River – 3.6)) ML/d
		Flow in Ovens River > 15.5 ML/d	5.5 ML/d

3.4 Other flow related issues

Bright and Porepunkah Weirs pool water to provide recreational and swimming amenities in these towns during summer (December to March). The weirs retard flow to downstream reaches as they fill, but have negligible impact on stream flow at other times. No water is harvested from the weirs and therefore they do not affect total annual flow volume, but they do restrict fish passage throughout this section of the upper Ovens River.

The Bright/Porepunkah Wastewater Treatment Plant (WWTP) currently discharges wastewater to a gravel pit which is approximately 400 m from the Ovens River. This discharge filters through to the Ovens River via the groundwater, but its effect on water quality and flow is unknown because the nearest downstream gauge is at Myrtleford. NERWA are currently upgrading the Porepunkah WWTP to treat wastewater to a tertiary standard. Tertiary treated wastewater will then be used to augment summer demands, which will potentially reduce the amount of water that is extracted from natural waterways during periods of low flow and high urban and agricultural demand.

3.5 REALM Model

Daily time series for current and natural flow for each reach were modelled using REALM (REsource ALlocation Model) to cover the period May 1891 to June 2005. Current flows are based on historic climate data and take account of the current level of development demands. Natural flows use historical climate data and assume no level of development demands (i.e. assume no extraction or farm dams). Changes to surface water run-off due to land clearing and increases in impervious area are not incorporated in these models and therefore the natural flow series is an estimate of the flows that may be expected in the catchment with the current land use but no extraction.

The extended time period (1891-current) for the Upper Ovens River REALM model increases the reliability and robustness of the modelled scenarios. Generally, the model outputs are a good estimation of flows at each site under natural and current conditions. The quality of the model calibration is good and within the accepted range for a REALM model, but as with any modelling process there are some limitations to the data outputs. There are a number of sources of uncertainty in the modelling process, these include:

- **Demands**- there are a number of assumptions made in order to model demands. The major demands in the Upper Ovens are direct irrigation demands. Limited metered data meant that the calibration of the models was less rigorous than it would otherwise have been. Similarly, there was no metered data for groundwater demands. A further limitation is that it is not possible to capture human psychology through the modelling process. For example, the impact of urban restrictions depends on community participation and it is difficult to judge how effective they will be.
- **Historic level of development**- the historic level of development demands have been modelled based on knowledge about agricultural trends in the region. These are not as accurate as recorded data would be.

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- **Gauged Flow Data-** inflows into the REALM model have been calibrated to gauged data plus historic demands. Where there is less gauged data available the calibration will be less rigorous.
- **Calibration of HYDROLOG models-** HYDROLOG models were used both to derive REALM inflow and disaggregate weekly flows to a daily timestep. In some cases the calibration was more difficult than in others. Similarly, some fits will be stronger over one portion of the flow record than over another.

Table 3-6 provides an overview of the level of confidence in each of the current and natural flow series and outlines the limitations of the assumptions underpinning their development. There is little development impact in the upper reaches of the study area and modelled flow scenarios in these reaches are quite reliable. However, extraction and farm dam impacts increase further downstream and errors associated with estimating these impacts reduces the confidence of modelled outputs for reaches in the lower section of the Upper Ovens River catchment. A full description of the REALM model development for the Upper Ovens River is provided in (SKM 2006b).

- **Table 3-6 Level of confidence in REALM outputs for each of the Upper Ovens River study reaches**

Location	Relative Confidence level	Discussion
Flows at Ovens River site between Harrietville- Bright	Very High	There are limited upstream demands and as a result there were not many assumptions about demands made throughout the modelling process. In addition, there is a long period of data at this site meaning that there was a lot of data available for calibration of inflows. The major demand, surface water irrigation demands were calibrated to metered data at this site and therefore there is a relatively high level of confidence in the modelling.
Morses Creek	High	Again, there are limited upstream demands and as a result there were not many assumptions made throughout the modelling process. Rigorous inflow calibration due to the long period of data available. There were no metered irrigation demands for this reach. This means that there is less confidence in the demands for this site. The pattern of daily flow was did not capture very low flow events; however, this is believed to be due to human factors and is therefore accounted for in the REALM outputs.
Flows at Ovens River site between Morses Creek and Buckland River	High	There is a long period of data at this site meaning that there was a lot of data available for calibration of inflows. The major demand, surface water irrigation demands were calibrated to metered data for the intermediate demands at this site. This means that there is a relatively high level of confidence this

Location	Relative Confidence level	Discussion
		modelling.
Buckland River	Very High	There are limited upstream demands and as a result there were not many assumptions made throughout the modelling process. In addition, there is a long period of data at this site meaning that there was a lot of data available for calibration of inflows. The major demand, surface water irrigation demands were calibrated to metered data at this site and therefore there is a relatively high level of confidence in the modelling.
Flows at Ovens River site between Buckland River and Buffalo River	Moderate	There was a considerable amount of data available for calibration of inflows, however the gauge does not record high flows and as a result it was not possible to calibrate over the high flow periods. There are a relatively high number of groundwater demands over this reach. There were no metered groundwater demands and as a result there is less confidence in the groundwater calculations. Finally, the intermediate reach for this site is a losing reach for very low flows. Whilst the REALM model has a loss function this means that there is less confidence in low flows over this reach.
Buffalo Creek	High	Again, there are limited upstream demands and as a result there were not many assumptions made throughout the modelling process. There is a reasonable period of data available at this site and therefore the calibration of inflows was more rigorous. There were no metered irrigation demands. This means that there is less confidence in the demands for this site.
Happy Valley Creek	Moderate	The Happy Valley Creek inflow calibration was relatively poor. In addition, this site has a high volume of demands. This means that there is additional scope for error.
Barwidgee Creek	Moderate	It was difficult to fit a HYDROLOG model to this site. This was compounded by the fact that there was a relatively short period of gauged data at this site.

3.6 Current vs natural flows

The following sections show plots and present summary statistics from the modelled current and natural flow series for each of the environmental flow study reaches. These data are useful for highlighting where and when development demands have the greatest effect on streamflow, but it should be noted that contrasts of average daily flow patterns do not reflect the impact that demands have on surface water flow in very dry years.

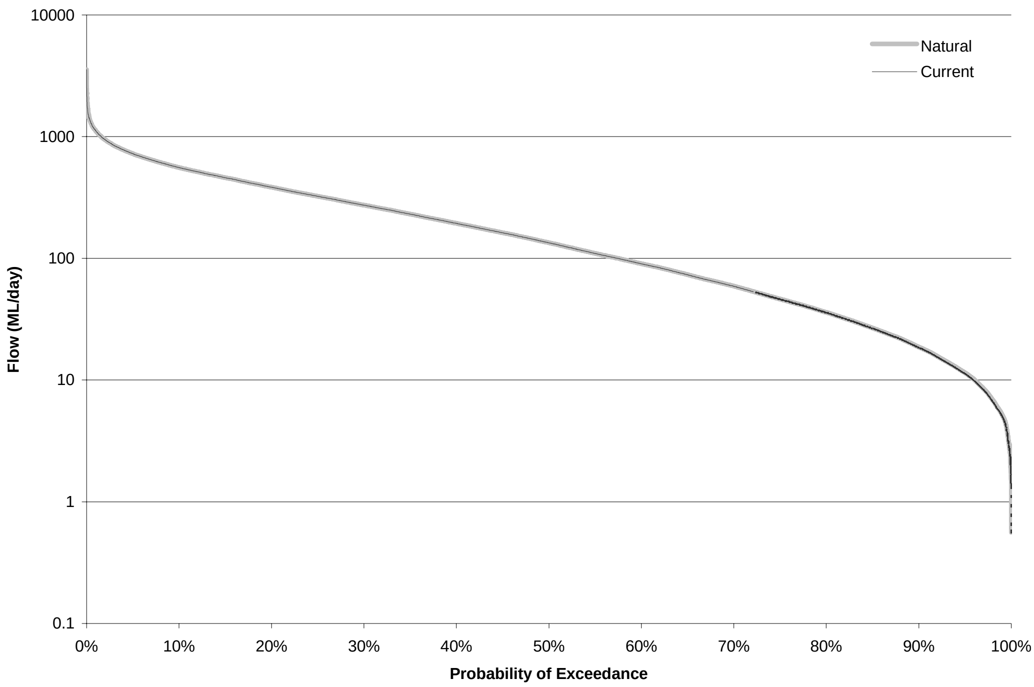
3.6.1 Reach 1: Ovens River upstream of Morses Creek

The FLOWS site for the Ovens River upstream of Morses Creek is located downstream of Harrietville and downstream of the confluence of the Ovens River East Branch and the Ovens River West branch. There are limited upstream demands of this site. The exception to this is water supply to Harrietville, which takes water from Simmons Creek. The limited upstream demands are demonstrated by fact that there is very little difference between the current and natural flow duration curves shown in (Figure 3-1).

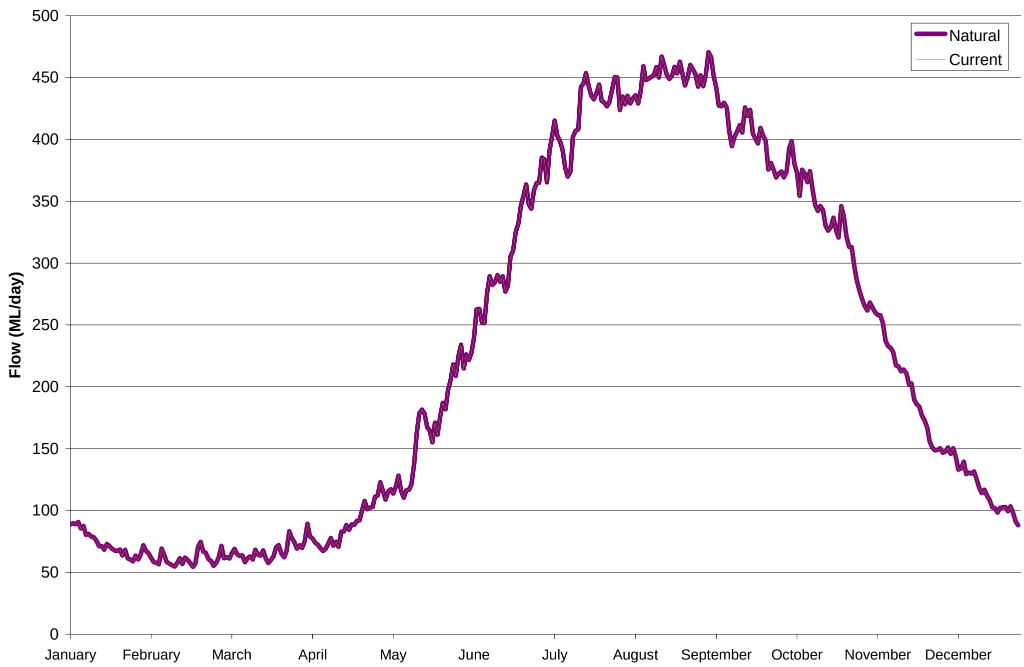
The mean natural annual flow in this reach is approximately 82,000 ML. Lowest flows occur in February and March, highest flows are recorded during winter (Figure 3-2). The plot of average daily flows shows little difference between the modelled natural, current and full entitlement flow series (Figure 3-2). There are no cease to flow periods in this reach (Figure 3-1). This indicates that there is a high base flow contribution to the streamflow at this site. This is supported by previous research into the Upper Ovens system and demonstrates the high level of interactions between surface and groundwater in this region. The flow statistics presented in Table 3-7 indicate little effect of current water extractions in most years, however extractions may have a more noticeable effect in particularly dry years.

- **Table 3-7: Natural, current and full entitlement flow statistics for Ovens River upstream of Morses Creek**

Stats	Natural (ML/day)	Current (ML/day)	Full Entitlement (ML/day)
annual			
Mean	225.2	225.1	225.1
Median	134.4	134.2	134.2
80th Percentile	36.0	35.7	35.7
20th Percentile	384.2	384.1	384.1
summer			
Mean	94.7	94.5	94.5
Median	52.0	51.8	51.8
80th Percentile	19.3	19.1	19.1
20th Percentile	134.8	134.6	134.6
winter			
Mean	356.1	355.9	355.9
Median	293.8	293.6	293.6
80th Percentile	134.3	134.2	134.2
20th Percentile	538.6	538.4	538.4



- **Figure 3-1 Natural and current flow duration curves in the Ovens River upstream of Morses Creek**



- **Figure 3-2: Average daily natural and current flows for each day of the year in the Ovens River upstream of Morses Creek. Plots are based modelled flows from 1891-2005**

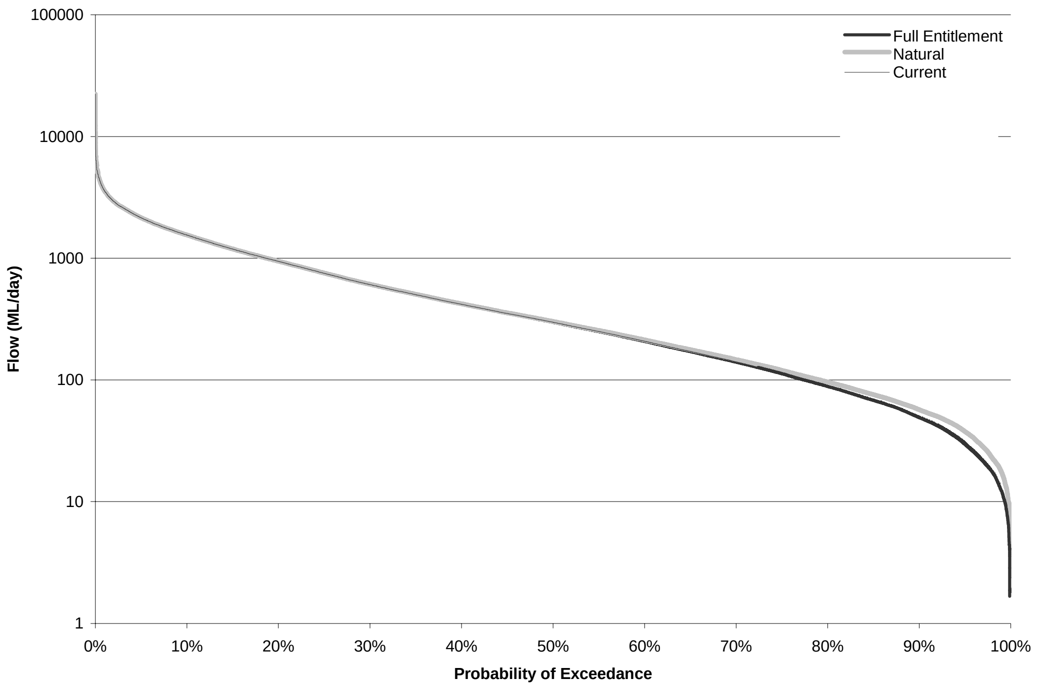
3.6.2 Reach 2: Ovens River between Morses Creek and Buckland River

This reach is located downstream of the confluence with Bakers Gully Creek which supplies some of Bright's town water supply. Other major demands upstream of this site include irrigation along Morses Creek and from the Ovens main stem. Modelled flow duration curves for this reach show a slight reduction in the magnitude of low flows under current flow conditions compared to the natural flow regime (Figure 3-3).

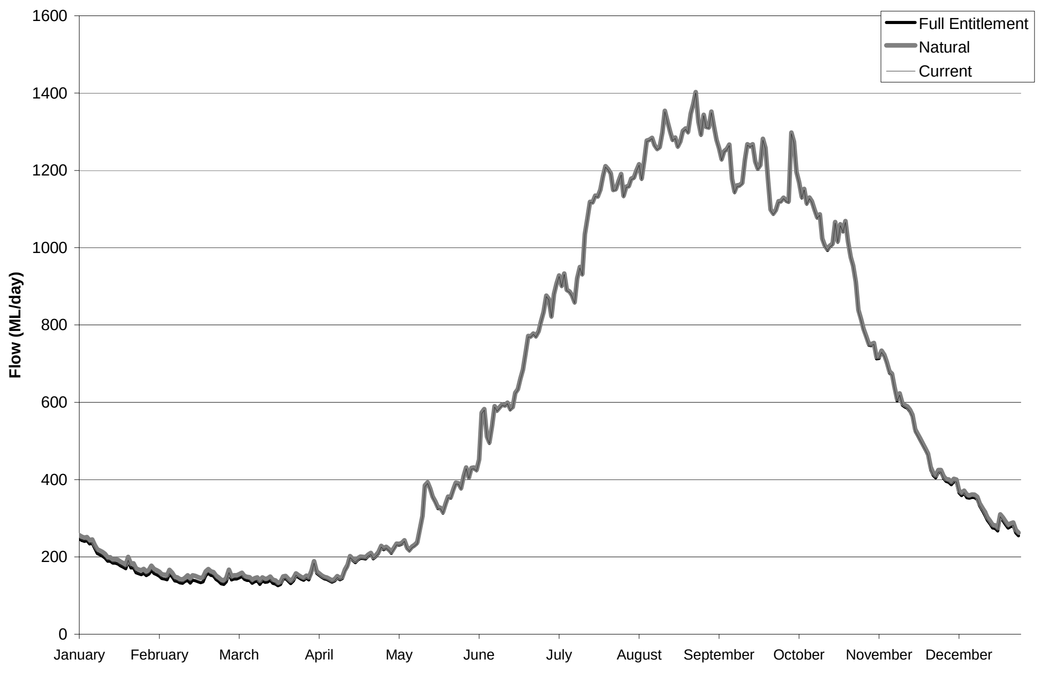
The mean natural annual flow in this reach is approximately 217,000 ML. Lowest flows occur in February and March, highest flows are recorded during winter (Figure 3-4). The plot of average daily flows shows little difference between the modelled natural, current and full entitlement flow series, but water extractions can reduce summer flow. Current extractions have no detectable effect on winter flow patterns and show little effect on summer freshes (20th percentile). Summer low flows are reduced by approximately 12% (80th percentile) (Table 3-8). No cease to flow periods are expected under natural or current conditions for this reach.

- **Table 3-8: Natural, current and full entitlement flow statistics for Ovens River between Morses Creek and Buckland River**

Stats	Natural (ML/day)	Current (ML/day)	Full Entitlement (ML/day)
annual			
Mean	595.3	590.7	590.1
Median	302.6	297.8	297.5
80th Percentile	96.3	89.6	88.4
20th Percentile	944.9	942.1	942.0
summer			
Mean	221.9	215.6	214.5
Median	135.9	128.8	127.6
80th Percentile	59.3	52.3	51.0
20th Percentile	307.3	301.3	300.8
winter			
Mean	969.5	966.6	966.5
Median	676.8	674.3	674.3
80th Percentile	298.3	295.0	294.9
20th Percentile	1516.3	1513.4	1513.4



- **Figure 3-3 Natural and current flow duration curves in the Ovens River between Morses Creek and Buckland River**



- **Figure 3-4: Average daily natural and current flows for each day of the year in the Ovens River between Morses Creek and Buckland River. Plots are based modelled flows from 1891-2005**

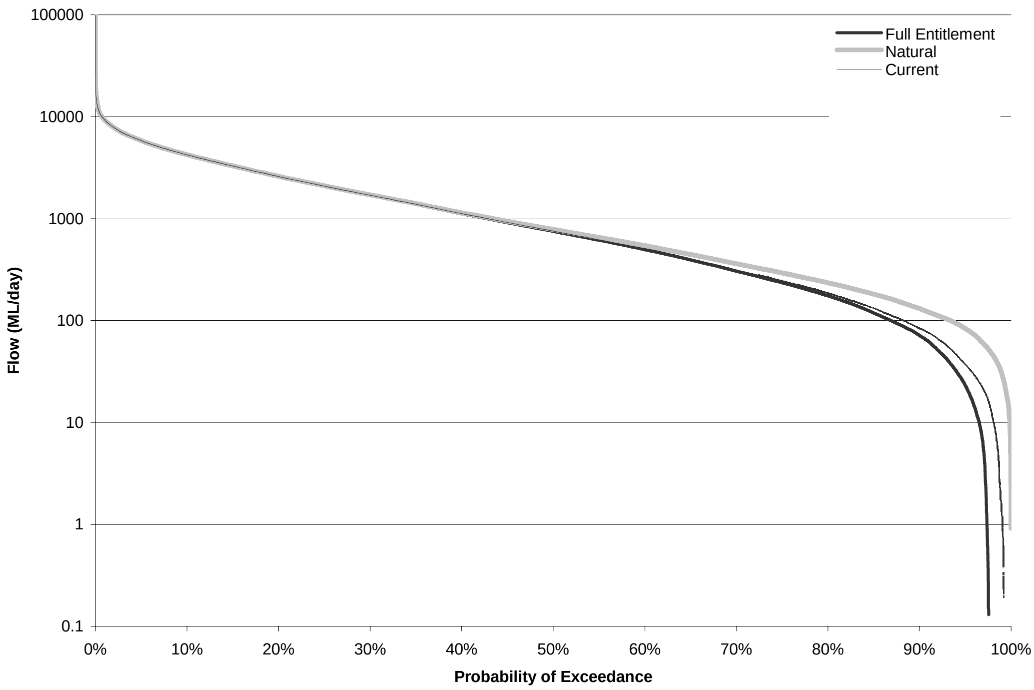
3.6.3 Reach 3: Ovens River between Buckland River and Buffalo River

The Ovens River between Buckland River and Buffalo River is downstream of the urban offtake points for Bright, Myrtleford, Harrietville and Porepunkah. There are also significant rural demands upstream of the site. This means that there is a more noticeable difference between natural and current flows than for the upstream Ovens River mainstem sites (Reach One and Reach Two).

The mean natural annual flow in this reach is approximately 584,000 ML. Lowest flows occur between February and April and the highest flows are recorded during winter (Figure 3-6). The plot of average daily flows shows little difference between the modelled natural, current and full entitlement flow series, but water extractions can reduce summer flow. Current extractions have no detectable effect on winter flow patterns and show little effect on summer freshes (20th percentile) which are reduced by 6% under current conditions (Table 3-9). Summer low flows are reduced by approximately 20% (80th percentile) through extractions upstream (Table 3-9). The Ovens River in this reach would not cease to flow under natural conditions, but the flow duration curves show that some cease-to-flow events can occur as a result of high summer demand under the current flow conditions (Figure 3-5).

- **Table 3-9: Natural and current flow statistics for Ovens River between Buckland River and Buffalo River**

Stats	Natural (ML/day)	Current (ML/day)	Full Entitlement (ML/day)
annual			
Mean	1599.8	1571.1	1565.8
Median	784.1	756.5	751.9
80th Percentile	234.6	186.0	175.1
20th Percentile	2604.6	2595.9	2595.7
summer			
Mean	610.5	562.7	553.4
Median	335.9	279.2	269.9
80th Percentile	136.9	87.2	75.0
20th Percentile	830.7	785.6	780.5
winter			
Mean	2591.0	2581.1	2580.2
Median	1869.5	1859.8	1859.3
80th Percentile	741.0	730.3	727.3
20th Percentile	4107.0	4100.4	4100.4



- **Figure 3-5 Natural and current flow duration curves in the Ovens River between Buckland River and Buffalo River**

- **Figure 3-6: Average daily natural and current flows for each day of the year in the Ovens River between Buckland River and Buffalo River. Plots are based modelled flows from 1891-2005**

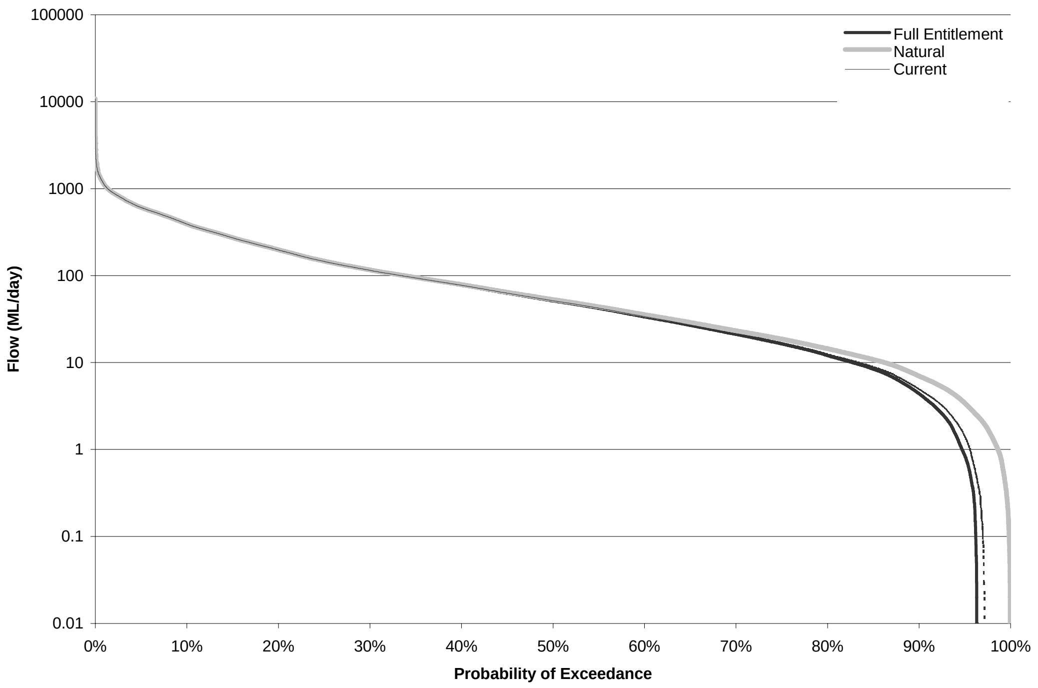
3.6.4 Reach 4: Morses Creek

Morses Creek is located in the upper reaches of the catchment and is the first of the Ovens River tributaries to have significant irrigation demands. Other demands include stock and domestic, commercial and industrial, there are also a small number of farm dams in this catchment. Irrigation in the region is dominated by tobacco plantations and orchards.

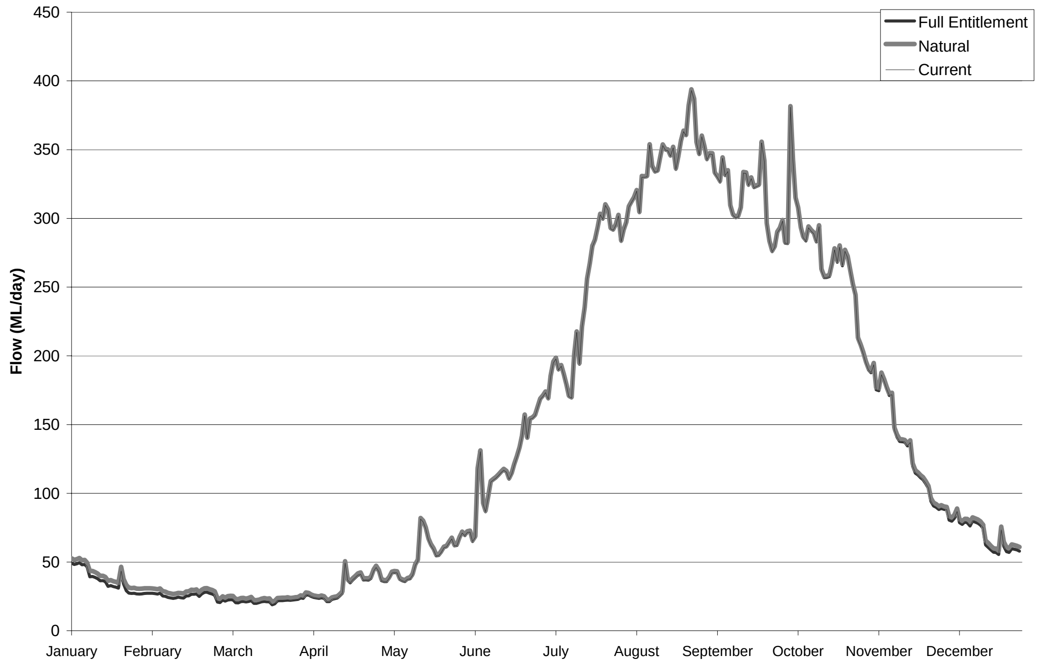
The mean natural annual flow in this reach is approximately 51,800 ML. Lowest flows occur between February and April and the highest flows are recorded during winter (Figure 3-8). The plot of average daily flows shows little difference between the modelled natural, current and full entitlement flow series, but water extractions can reduce summer flow. Current extractions have no detectable effect on winter flow patterns and have little effect on the magnitude of summer freshes (see 20th percentile statistic in Table 3-10). However, during summer, irrigation demands reduce the low flow by 30% (see 80th percentile in Table 3-10). Cease to flow events would have been very rare in Morses Creek under natural flow conditions, but this stream now ceases to flow for nearly 3% of the time (Figure 3-7).

- **Table 3-10: Natural, current and full entitlement flow statistics for Morses Creek**

Stats	Natural (ML/day)	Current (ML/day)	Full Entitlement (ML/day)
annual			
Mean	141.6	140.1	139.9
Median	53.1	51.4	51.2
80th Percentile	14.4	12.5	12.1
20th Percentile	198.2	197.1	197.1
summer			
Mean	42.5	40.5	40.2
Median	21.7	19.7	19.7
80th Percentile	7.6	5.4	5.4
20th Percentile	59.6	57.5	57.5
winter			
Mean	240.8	239.8	239.8
Median	129.0	127.9	127.8
80th Percentile	47.5	46.4	46.4
20th Percentile	383.1	382.2	382.2



- **Figure 3-7 Natural and current flow duration curves in Morses Creek**



- **Figure 3-8: Average daily natural and current flows for each day of the year in Morses Creek. Plots are based modelled flows from 1891-2005**

SKM

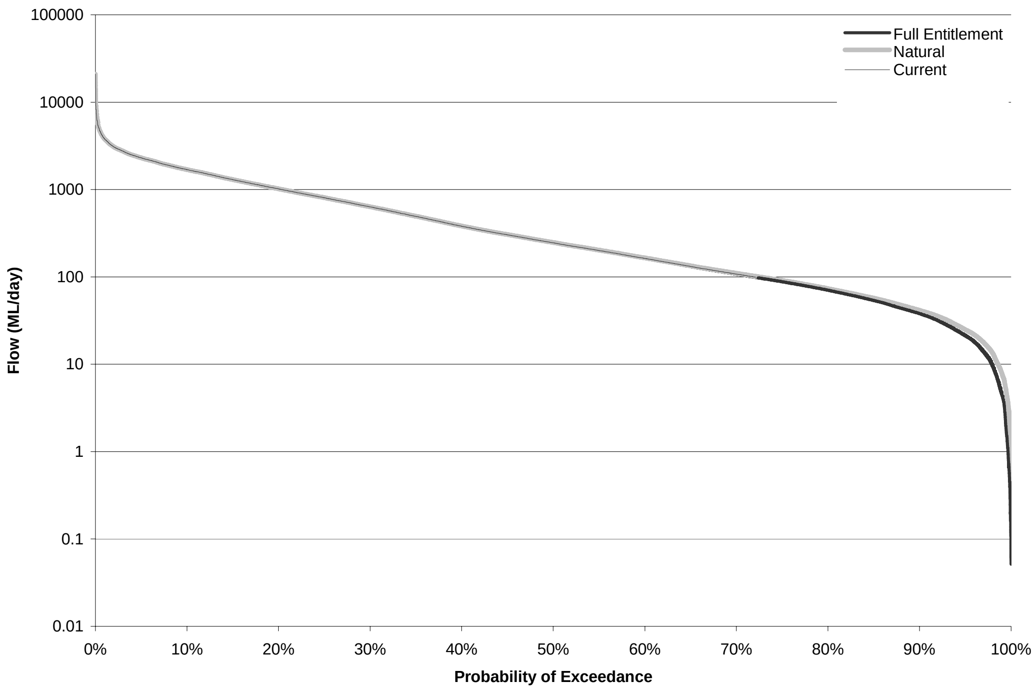
3.6.5 Reach 5: Buckland River

The Buckland River flows north from Mt Selwyn in the Alpine National Park to the Ovens River at Porepunkah. Most of the catchment is forested and lies in the Alpine and Mount Buffalo National Parks and there are limited upstream demands, but the lower third of the floodplain has been cleared and is used for apple and nut crops as well as stock production. Licensed diverters can harvest up to 490 ML/year from the Buckland River and its tributaries for irrigation and stock watering. The Porepunkah town supply draws between 100 and 200 ML/year from the Buckland River in most years, but in 2003/04 Porepunkah's urban demand was 233 ML

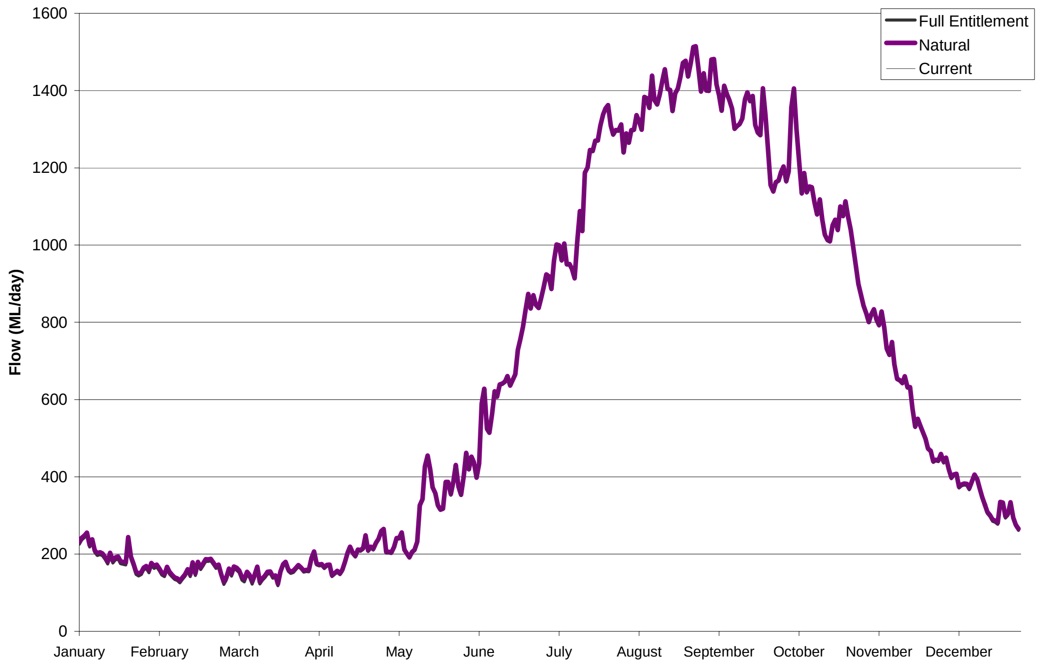
Mean annual flow in this reach is approximately 220, 000 ML. Average daily flows are lowest at the end of summer (January to April) and are highest in winter (Figure 3-10). The plot of average daily flow shows little difference between the modelled current, natural and full entitlement flow series (Figure 3-10), but water extractions can reduce summer flows in the Buckland River during dry years. Current extractions have no detectable effect on winter flow patterns and have little effect on the magnitude of summer freshes (see 20th percentile statistic), but reduce the magnitude of the summer low flow by approximately 10% (see 80th percentile) (Table 3-11) and slightly increase the duration and frequency of cease-to-flow events (Figure 3-9). Under natural conditions, the Buckland River almost never ceased-to-flow, but some cease to flow events are predicted under current conditions because irrigation demands are generally greatest during summer when stream flows would be naturally low (Figure 3-9). This is supported by reports of some cease-to-flow periods in this river during particularly dry years (Matthew O'Connell, Environmental Water Resources Officer North East CMA).

- **Table 3-11: Natural, current and full entitlement flow statistics for Buckland River**

Stats	Natural (ML/day)	Current (ML/day)	Full Entitlement (ML/day)
annual			
Mean	610.1	607.9	607.6
Median	247.7	245.6	245.3
80th Percentile	73.4	71.1	70.4
20th Percentile	1018.8	1017.3	1017.3
summer			
Mean	230.0	226.6	225.7
Median	112.8	109.8	108.8
80th Percentile	46.1	42.6	41.4
20th Percentile	292.1	288.8	288.5
winter			
Mean	1048.1	1046.1	1046.1
Median	734.8	733.0	733.0
80th Percentile	226.2	224.1	223.9
20th Percentile	1715.1	1713.3	1713.3



▪ **Figure 3-9 Natural, current and full entitlement flow duration curves in the Buckland River**



▪ **Figure 3-10 Average daily natural, current and full entitlement flows for each day of the year in the Buckland River. Plots are based modelled flows from 1891-2005**

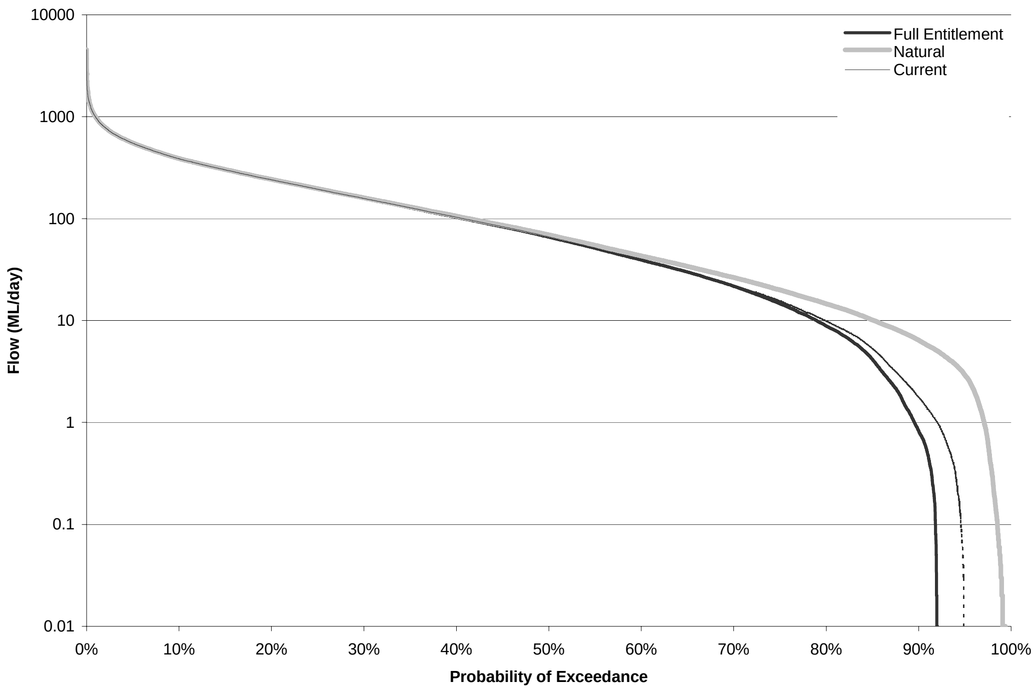
3.6.6 Reach 6: Buffalo Creek

Buffalo Creek is located in the lower part of the Upper Ovens catchment and supplies water to Myrtleford. Irrigation on Buffalo Creek is dominated by tobacco, but the catchment also has some vineyards. Other demands include stock and domestic use and farm dams.

Mean annual flow in this reach is approximately 54,400 ML. Average daily flows are lowest at the end of summer (January to April) and are highest in winter (Figure 3-12). The plot of average daily flow shows little difference between the modelled current, natural and full entitlement flow series (Figure 3-12), but water extractions can reduce summer flows in Buffalo Creek during dry years. Current extractions have no detectable effect on winter flow patterns and have little effect on the magnitude of summer freshes (see 20th percentile), but reduce the magnitude of the summer low flow by approximately 70% (see 80th percentile) (Table 3-12) and increase the duration and frequency of cease-to-flow events (Figure 3-11). Under natural conditions, Buffalo Creek rarely ceased-to-flow, but under current conditions the stream ceases to flow on average for 5% of the time due to high irrigation demands in summer (Table 3-11).

- **Table 3-12: Natural, current and full entitlement flow statistics for Buffalo Creek**

Stats	Natural (ML/day)	Current (ML/day)	Full Entitlement (ML/day)
annual			
Mean	149.2	146.1	145.7
Median	69.4	66.2	65.9
80th Percentile	14.6	9.9	8.9
20th Percentile	243.2	240.6	240.6
summer			
Mean	68.3	64.3	63.6
Median	25.0	20.3	19.4
80th Percentile	7.0	2.1	1.0
20th Percentile	89.7	85.7	85.2
winter			
Mean	230.2	228.1	228.0
Median	155.8	153.8	153.8
80th Percentile	54.8	52.7	52.7
20th Percentile	357.7	356.0	356.0



■ **Figure 3-11 Natural and current flow duration curves in Buffalo Creek**

■ **Figure 3-12: Average daily natural and current flows for each day of the year in Buffalo Creek. Plots are based modelled flows from 1891-2005**

3.6.7 Reach 7: Happy Valley Creek

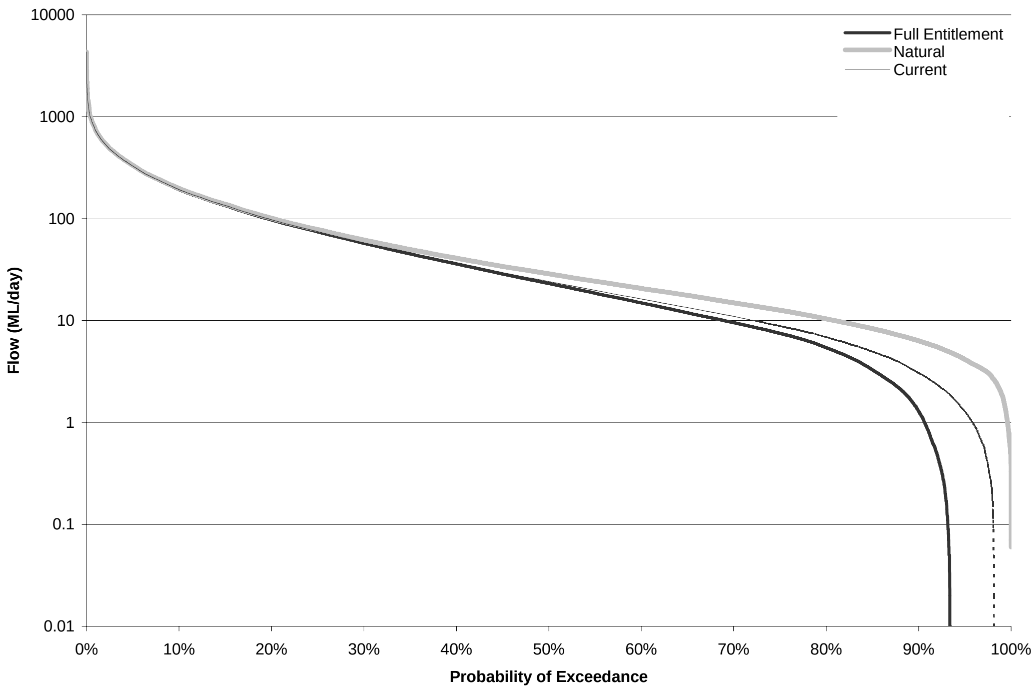
Happy Valley Creek is one of the lowest tributaries in the Upper Ovens catchment. It merges with Barwidgee Creek before entering the Ovens River at Myrtleford. Happy Valley creek has a high concentration of farm dams. Irrigation is dominated by annual pasture and tobacco.

Mean annual flow in this reach is approximately 29,200 ML. Average daily flows are lowest at the end of summer (January to April) and are highest in winter (Figure 3-14). The plot of average daily flow shows little difference between the modelled current, natural and full entitlement flow series (Figure 3-14), but water extractions can reduce summer flows in Happy Valley Creek during dry years. Current extractions have no substantial effect on winter flow patterns. Current demands reduce the magnitude of summer freshes by approximately 16% (see 20th percentile), and the magnitude of the summer low flow by approximately 50% (see 80th percentile) (Table 3-13)

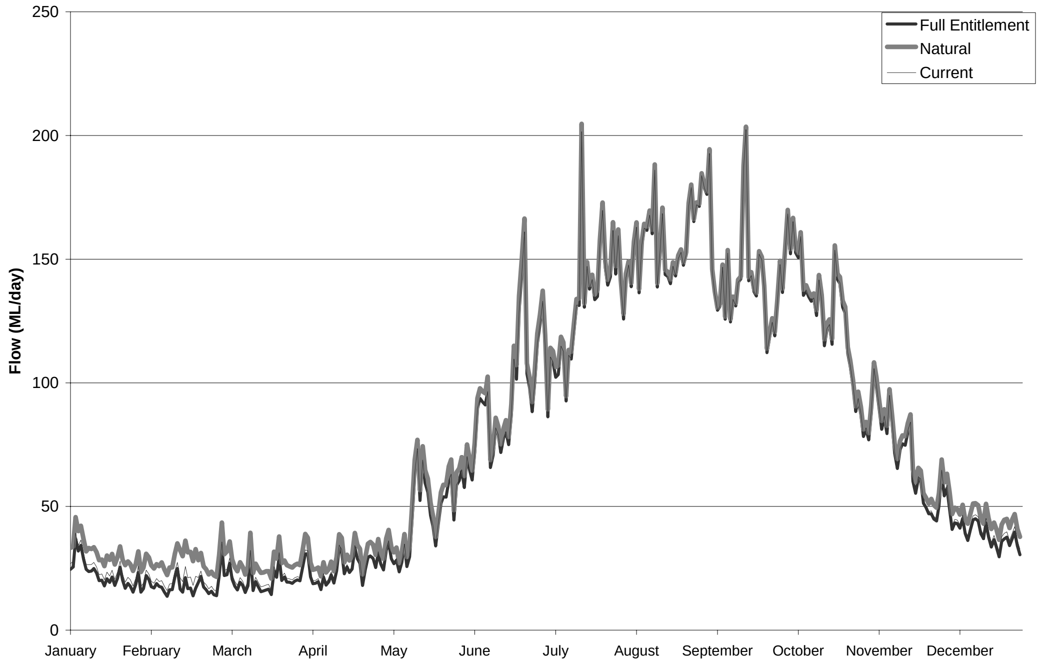
Figure 3-13 shows the flow duration curve for natural and current flows at Happy Valley Creek. These plots show that the current level of development has a noticeable impact on flows from the 60th percentile level. In addition, cease to flow events do not occur under natural conditions but are evident under current development (Figure 3-13).

- **Table 3-13: Natural, current and full entitlement flow statistics for Happy Valley Creek**

Stats	Natural (ML/day)	Current (ML/day)	Full Entitlement (ML/day)
annual			
Mean	79.8	75.8	74.9
Median	28.8	24.2	23.1
80th Percentile	10.4	6.9	5.4
20th Percentile	101.0	97.6	97.2
summer			
Mean	35.9	30.4	28.7
Median	17.0	11.9	9.8
80th Percentile	7.3	3.7	1.7
20th Percentile	39.7	33.3	31.7
winter			
Mean	123.8	121.3	121.1
Median	60.0	57.5	57.4
80th Percentile	19.0	16.8	16.5
20th Percentile	175.2	172.6	172.6



- **Figure 3-13 Natural and current flow duration curves in Happy Valley Creek**



- **Figure 3-14: Average daily natural and current flows for each day of the year in Happy Valley Creek. Plots are based modelled flows from 1891-2005**

SKM

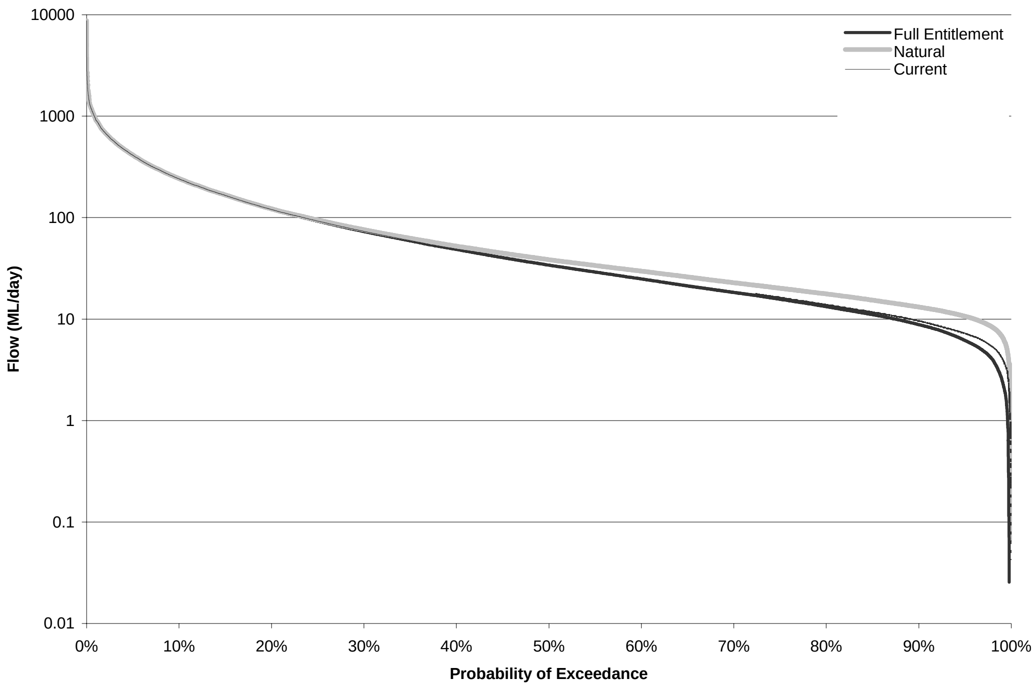
3.6.8 Reach 8: Barwidgee Creek

Barwidgee Creek flows south west from Mt Jack and the Pinnacles and joins the Ovens River at Myrtleford. Most of the Barwidgee Creek catchment has been cleared and is primarily used for apple and tobacco crops as well as livestock production. Licensed irrigators can harvest up to 658 ML/year from the catchment.

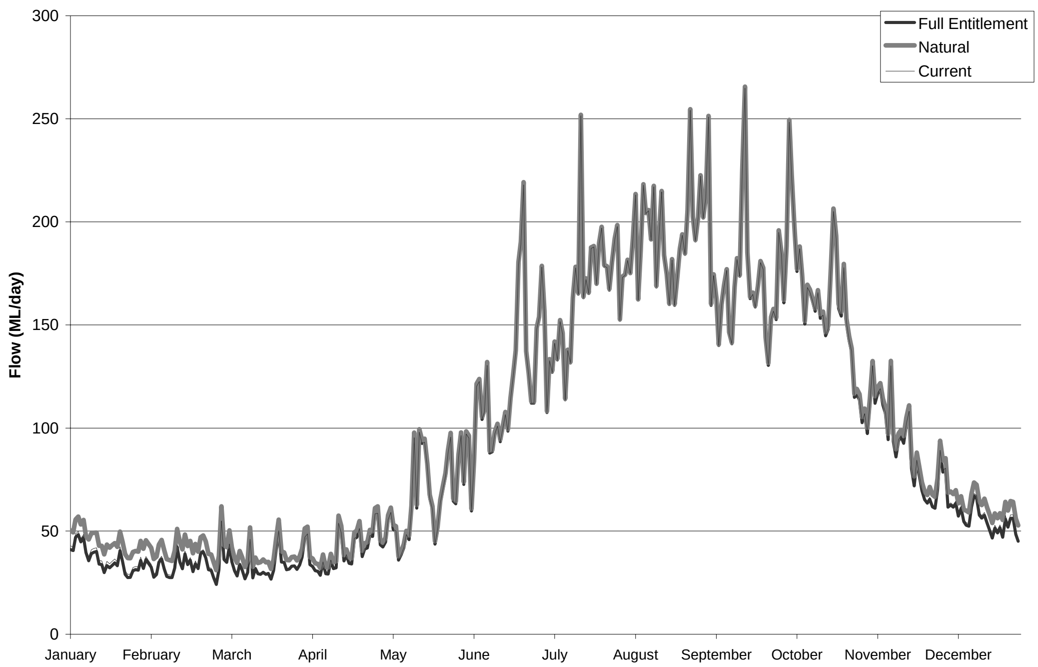
Mean annual flow in this reach is approximately 37,200 ML. Average daily flows are lowest at the end of summer (January to April) and are highest in winter (Figure 3-16). The plot of average daily flow shows little difference between the modelled current, natural and full entitlement flow series (Figure 3-16), but water extractions can reduce summer flows in Barwidgee Creek during dry years. Current extractions have no substantial effect on winter flow patterns. They reduce the magnitude of summer freshes by approximately 10% (see 20th percentile), and the magnitude of the summer low flow by approximately 29% (see 80th percentile) (Table 3-14). Cease-to-flow periods are not expected under natural or current conditions (Figure 3-15).

Table 3-14: Natural, current and full entitlement flow statistics for Barwidgee Creek

Stats	Natural (ML/day)	Current (ML/day)	Full Entitlement (ML/day)
annual			
Mean	101.5	98.3	97.9
Median	38.5	34.6	34.0
80th Percentile	17.7	13.8	13.2
20th Percentile	122.0	120.1	119.9
summer			
Mean	50.3	45.2	45.3
Median	27.3	21.9	21.9
80th Percentile	15.9	11.3	11.3
20th Percentile	55.8	50.5	50.5
winter			
Mean	152.8	151.5	151.5
Median	74.0	72.6	72.7
80th Percentile	27.8	26.3	26.3
20th Percentile	210.7	210.4	210.4



- **Figure 3-15 Natural, current and full entitlement flow duration curves in Barwidgee Creek**



- **Figure 3-16 Average daily natural and current flows for each day of the year in Barwidgee Creek. Plots are based modelled flows from 1891-2005**

3.7 Summary

Water extraction has had little effect on winter flow in the upper Ovens River, but has reduced the magnitude of summer low flows and summer freshes. The extent of flow alterations varies throughout the upper Ovens River catchment. Summer flow reductions generally increase from reach one to reach three in the main stem of the Ovens River, but are most pronounced in smaller tributaries. Water demands in Happy Valley Creek, Barwidgee Creek, Buffalo Creek, and Morses Creek account for a substantial proportion of the natural summer flow in these catchments and can reduce or even stop flow during peak summer extraction periods.

4. Geomorphology

The Upper Ovens catchment is characterised by hilly to mountainous terrain on lower Paleozoic sedimentary rocks. The valley is bounded by high peaks including: Mt Hotham, Mt Selwyn, Mt Saint Bernard, Mt Feathertop and Mt Buffalo (Cottingham *et al.* 2001, G-MW 2003). The Ovens River rises on the slopes of Mt Hotham to flow down a relatively steep sided valley dominated by bedrock, where it is joined by numerous small tributaries including Stony, Smoko, Shamrock and Snowy Creeks. The size of the river increases as it flows from the mountain ranges with a considerable increase in size at Bright downstream of its confluence with Morses Creek. Downstream from Bright, the river grade flattens and a broad floodplain is developed. At Porepunkah the Ovens River is joined by the Buckland River and the channel broadens further (G-MW 2003).

The upper Ovens River is partially confined cobble bed with the Buckland River being bedrock confined cobble bed. Benches are common within the upper reaches and are dominated by lee feature benches, largely from the presence of bedrock controls and large woody debris (Vietz *et al.* in prep). The streambed along the length of the river is a combination of very coarse gravels, rocks and sand (G-MW 2003).

There has been considerable human impact on the geomorphology of the upper Ovens River particularly between Bright and Myrtleford: gold mining, river improvement works, willow invasion and intensive floodplain cultivation (Shugg 1985). Alluvial gold mining of the Upper Ovens River commenced in the 1850’s and continued until the 1950’s with activity concentrated above Porepunkah, extending down to Myrtleford. As a result the natural channel of the Ovens River above Porepunkah was severely degraded with a large load of sand and gravel released into the River below Bright. Over time, the upper reaches have largely recovered from the dredging, however the sediment slug remains and is gradually working its way down the system (Cottingham *et al.* 2001).

Intensive agriculture within the upper reaches of the Ovens River has also impacted on stream condition. Tobacco cultivation in the 1950’s marked the most intensive use of the floodplain with tobacco planted right down to the river edge. The upper reaches have a history of avulsions particularly where the floodplain is cleared for intensive landuse. In addition, stream condition has been impacted by channel improvement works and willow invasion (Cottingham *et al.* 2001).

4.1 Reach condition assessment

4.1.1 Ovens River: headwaters to Morses Creek

This reach is partially confined as the channel meanders from valley side to valley side across a small floodplain. The stream is well connected with its floodplain through a variety of floodrunners and other preferred flow paths. There is a long history of floodplain modification (particularly in the vicinity of Harrietville) from dredging for gold.

DNRE (1999) reported that 11 mines operated at various times in the Harrietville district between 1860 and 1954. Of these operations, one operated a dredge on leased river flats totalling 356 hectares. The leases extended southwards for 7 km from a point halfway between Stoney and Smoko Creeks. The bucket dredge was the biggest in the Southern Hemisphere: it measured 167 metres long, weighed 4,813 tonnes, and could dredge to a depth of approximately 41 metres (DNRE 1999). The dredge commenced operations in 1942 but manpower restrictions during WW2 meant that it was1946 before operations commenced in earnest. Dredging continued until 1954 when the operation became unprofitable. The company failed to honour the land rehabilitation and reclamation covenants on its leases.

Today, remnants of the dredge workings remain on the floodplain in the form of dredge ponds and tailings dump (now covered by pines). However, the contemporary channel appears to be adjusted to the floodplain and now appears to be relatively stable. The current stream management issue is the consolidation of gravels (probably there as a result of past mining) by willows. The willows have encroached into the channel and a number of extensive mid-channel bars can now be observed where willows have caused the channel to bifurcate. Indeed, the dominant feature of the reach is the extensive willow infestation of the riparian zone and floodplain.

4.1.2 Ovens River: Morses Creek to Buckland River

For most of this reach, the stream flows through a bedrock gorge. Due to the bedrock control, there are no particular channel stability issues of note but past mining activities have left a legacy of introduced sediment in the river. Sluicing was conducted on an extensive scale at Bright from 1856, with a large claim carving out a feature in the landscape now known as “The Canyon” (DNRE 1999). The Canyon is a massive sluiced open cut extending along the western side of the Ovens River.

Through the pebble dumps of The Canyon run several tailraces that have been cut into the bedrock to drain the site into the river. According to DNRE a walking track (the Canyon Walk) follows the western bank of the river, crossing at least 12 tailraces, some by small bridges. Towards the northern end of the workings, the alluvial ground was shallower and the pebble dumps and tailraces extend directly to the river. Sections of the open cut have now been rehabilitated for residential development. Workings are very overgrown, and some of the tailrace cuttings have been filled. The site is probably no longer an active sediment source to the river.

4.1.3 Ovens River: Buckland River to Buffalo River

Geomorphologically, this is probably the most interesting reach. Here, the capacity of the river reduces with increased distance downstream (ID&A 1997). As a result, an increased proportion of flood flows are discharged over the floodplain. The sinuosity of the river is increased and the channel is perched on the floodplain. Indeed the course of the Ovens River is situated on one of the highest parts of the floodplain and there are local concerns of an avulsion of the channel into the nearby Happy Valley Creek. The invert of Happy Valley Creek is substantially lower than that of the Ovens River, so despite rock protection of nickpoints that are eroding a new course between the two streams, an avulsion at this site is inevitable. Aside from the rockwork to stabilise the current stream course, willows abound in this reach and exert a profound influence over the evolution of the channel and are probably contributing to the risk of avulsion (Ladson *et al.* 1997). This combined with past gold mining activities and current agricultural development leave the condition of the reach in a very poor state.

4.1.4 Morses Creek

Morses Creek is a small steep channel confined to the valley axis and well connected to the adjacent hillslopes. The channel has been straightened considerably through the town of Wandiligong and has been subject to extensive willow invasion. At the site that we surveyed the channel is influenced by weak mudstones that form a stepped-pool morphology. Where this material is exposed to the air, it weathers rapidly and becomes quite friable. Due probably to the straightening, the channel has incised and old bed sediments (cobbles and gravels) have been exposed in steep eroding banks.

The channel straightening is a legacy of active mining in the catchment, particularly near Wondiligong, from about 1860 up until the First World War. After the war the diggings were largely superseded by dredging operations. According to DNRE (DNRE 1999) dredging was active from 1924 until 1930 on the Morses Creek and Growlers Creek flats. The effects of the dredging have been quite profound for the channel as exemplified by the flood of October 1993 in Morses Creek, that caused the loss of five road bridges (ID&A 1997). In each instance, the abutments and approaches to the bridges were washed away due to erosion of the underlying dredge tailings. Extensive stream stabilisation works have been undertaken since the flood. However, lateral stability remains an issue for the lower reaches of the creek.

4.1.5 Buckland River

The Buckland River was sluiced for gold from about 1855. By 1960 a network of water-races had been established and the river's course was already choked with tailings from sluicing claims on the banks (DNRE 1999). The higher flats were worked by hydraulic sluicing, using large sluice boxes and a strong head of water (hence the water-races), while the waterways and the lower flats were ‘paddocked’ or stripped of their goldless overburden and the washdirt then raised to the sluice. Sluicing for gold peaked in the mid 1860s but had largely wound down by 1871 as winnable gold dwindled. However, some sluicing continued with sluicing on a high terrace, about 11 km south of Porepunkah, last reported in the 1950s. In common with other sites on the Ovens River and

Morses Creek, the Buckland River's floodplain was bucket dredged from about the turn of the century until 1920.

A number of reaches of the lower Buckland River are relatively straight as a result of reconstruction following the gold mining (ID&A 1997). Yet, despite the mining operation and the constructed river alignment the river is relatively stable and retains high environmental values. ID&A did, however, report historic avulsions where the river left its channel in favour of a new course over dredge tailings. Indeed, according to ID&A, the newly formed channel was actively developing a new meander pattern through the dredge tailings in 1997.

The Buckland River, in the vicinity of our assessment site is particularly stable as it is partially confined and bedrock controlled. In places, alluvial flats are developed, but for the most part, the channel is well connected to the adjacent hillslopes. Where not dominated by bedrock, the bed substrate is coarse cobbles. However, deep pools and runs are really controlled by the bedrock. We also observed some colonisation of cobble bars – which is probably a reflection of sustained lower flows during the drought. The right bank is heavily infested by willows and blackberries but the left bank retains its natural suite of vegetation. No LWD was observed in the channel which could be a reflection of the high energy that flood flows would develop down this reasonably steep channel.

4.1.6 Buffalo Creek

The lower reaches of Buffalo Creek typified by a small deeply incised channel. For the most part the riparian zone is completely dominated by willows and blackberries. (Indeed, observation of the channel was severely hampered by the dense stands of weeds on the banks). However, where observed, the bed appears quite planar and falls in long regular runs. The bed material is gravels and cobbles and these can be seen forming the lower half of the banks as well due to recent incision of the channel.

Higher up the creek ID&A (1997) reported that the creek has been subject to many years of stream management work. Streamside revegetation sites have been established in many places along the length of the creek adjacent to land cleared for agricultural uses.

4.1.7 Happy Valley Creek

The Happy Valley Creek has a history of stream management with a willow control program intitiated by the Ovens Creek Management Board in 1991 and subsequent bed and gully stabilisation undertaked by North East Waterways in 1993 (ID&A 1997). Despite this previous work, however, willow domination of the streambed and floodplain are priority stream management issues in the catchment. In some places, there is no definable stream course through the willows that have colonised the previous channel.

Elsewhere, and at our study site, the stream is subject to cattle access and the banks have been reshaped by cattle pads and more generalised pugging. Older (abandoned) channels can be observed on the floodplain which suggests a relatively dynamic fluvial environment. The contemporary channel is quite sinuous and is formed in series of pools and riffles at the bends and inflection points, respectively. Bed substrate is gravels with interstitial sands. Almost the only riparian vegetation is pasture grasses with recent willow removal otherwise denuding the riparian zone.

Importantly, the lower reach of the creek is lower than the Ovens River where it flows through Mytleford and may eventually capture the Ovens River (see Section 4.1.3).

4.1.8 Barwidgee Creek

Barwidgee Creek flows through a small steep catchment. At the time of their report, ID&A (1997) identified gully and streambank erosion in the upper Barwidgee Catchment as the most severe in the upper Ovens Catchment. The river channel is confined to the valley axis but small pockets of alluvium are observed in the lower valley where the terrain begins to open out. At the assessment site, the channel was quite deep with steep, well vegetated banks. Willows encroach on the channel and have caused a sinuous thalweg to bifurcate around vegetated mid-channel bars or shift laterally to accommodate bank attached willow bars. For the most part the bed substrate is medium cobbles that form into steep runs (the influence of the willows notwithstanding), punctuated by the occasional outcrop of bedrock.

Further down the valley, stream stability declines. Here, the creek conveys a high bedload of sand (presumably from the earlier phase of erosion higher in the catchment) that tends to accumulate in the channel as the stream grade flattens. The combination of high bedload and a previously dredged floodplain (particularly adjacent to Myrtleford: ID&A 1997) means that the stream is prone to breakouts and constant adjustment of its course.

4.1.9 Summary of reach condition and threats

The main geomorphological issues in the upper Ovens River are summarised for each of the study reaches in Table 4-1.

Table 4-1 Summary of current condition, flow impact and other issues affecting geomorphology in the Ovens River study area

Reach	Geomorphology issues
Reach 1: Ovens River upstream of the Morses Creek confluence	**General condition** ▪ Historically impacted by mining activities, but contemporary channel has adjusted and is now relatively stable ▪ Channel is well connected to floodplain **Flows:** ▪ Current freshes, high and bankfull flows aid channel recovery and maintenance and should be retained. **Threats and issues:** ▪ Extensive willow infestation
Reach 2: Ovens River from the Morses Creek confluence to the Buckland River confluence	**General condition** ▪ River flows through bedrock gorge and there are no stability issues ▪ Historic mining introduced high sediment load to the river. **Flows:** ▪ Flows likely to have little effect in this reach due to bedrock control. **Threats and issues:** ▪ Willows and blackberries present, but do not substantially affect geomorphology
Reach 3: Ovens River from the Buckland River confluence to the Buffalo River confluence	**General condition** ▪ Past gold mining activities, agricultural development and willows contribute to a poor overall condition for this reach. ▪ Channel perched on floodplain and is eroding a new course to the lower channel in the nearby Happy Valley Creek. **Flows:** ▪ High to bankfull flows in this reach are likely to spill into Happy Valley Creek and cause the river to avulse, this also deprives the lower part of this reach of bankfull flows. **Threats and issues:** ▪ Extensive willow infestation
Reach 4: Morses Creek	**General condition** ▪ Historically impacted by mining activities – the channel has been straightened, especially near Wandiligong ▪ Sections influenced by weak mudstone **Flows:** ▪ Current high and bankfull flows repairing channel impacts associated with mining and should be protected. **Threats and issues:** ▪ Extensive willow infestation ▪ Lateral stability of the channel

Reach	Geomorphology issues
Reach 5: Buckland River	**General condition** ■ Historically impacted by mining activities, but contemporary channel has adjusted and is now relatively stable although some isolated avulsions are evident ■ Some sections are bedrock controlled **Flows:** ■ Current freshes, high and bankfull flows aid channel recovery and maintenance and should be retained. **Threats and issues:** ■ Willows and blackberries are a problem in places
Reach 6: Buffalo Creek	**General condition** ■ Small, incised channel with riparian zone dominated by blackberries and willows. ■ Stream subject to many years of stream management works **Flows:** ■ Bankfull flows likely to be uncommon in this reach due to incised channel ■ Very large flows would break out of the channel near the Ovens floodplain **Threats and issues:** ■ Extensive blackberry infestation ■ Continued channel incision
Reach 7: Happy Valley Creek	**General condition** ■ Channel choked with willows – no defined stream course in some places ■ Active willow removal in places ■ Contemporary channel (where it exists) is sinuous with a series of pools and riffles. ■ Stock access have reshaped the banks in places **Flows:** ■ Current high and bankfull flows maintain channel forming processes and pool/riffle habitats and should be preserved.. **Threats and issues:** ■ Extensive willow infestation ■ Stock access
Reach 8: Barwidgee Creek	**General condition** ■ Extensive gully and streambank erosion in the upper part of the catchment ■ Willow encroachment has influenced the channel course in placles ■ High bedload and previous floodplain dredging mean the channel is prone to breakouts and changes in course. **Flows:** ■ Current freshes, high and bankfull flows aid channel recovery and maintenance and should be retained. **Threats and issues:** ■ Extensive willow infestation

4.2 General geomorphological management objectives and recommendations

General objectives for managing the geomorphology of the upper Ovens River are:

1) Flow related

   Protect high and bankfull winter flows to maintain natural channel forming processes; and

2) Non-flow related

   Remove weeds, particularly willows and blackberries, that are altering channel morphology and natural channel forming processes throughout the catchment. These weeds are having a greater effect than flow modification, or the past phase of gold mining, on contemporary channel geomorphology throughout the catchment. Indeed, weed removal should be considered one of the highest management priorities for the catchment but undertaken with assessment of the underlying channel stability of target reaches.

5. Vegetation

5.1 Background and Condition

The vegetation associated with upland creeks and rivers shows considerable diversity in plant communities and in growth-forms, from long-lived trees to ferns and mosses: this diversity is a direct expression of the range of hydro-geomorphic habitats available for plants. This section on vegetation groups this diversity into two habitats: *in-channel* and *riparian.* In-channel, as used here, refers to those plants growing under or through water on the bed of the stream, along the edge of the channel, and on bars and benches within the channel. It includes aquatic plants (sometimes called macrophytes), sedges, rushes and semi-aquatic plants: these plants are mostly non-woody. Riparian, as used here, includes plants growing on the vertical face of river banks and on the flood-prone land above the riverbank adjacent to the channel. Riparian vegetation includes trees, shrubs, ferns, mosses, grasses, and sedges, rushes and herbs in the understorey, and in this context, the introduced species such as blackberry and willow, because they are found in the riparian zone. Definitions of ‘riparian’ can vary according to whether the intent is legalistic or ecological. As used here, *riparian* corresponds to that used in the state-wide assessment protocol, the Index of Stream Condition or ISC.

The rationale for making a distinction between these two habitats is that they are quite different combinations of inundation frequency, inundation depth and duration, the role of velocity and the type of substrates available for the plants, as reflected in the term hydrogeomorphic.

5.1.1 Available data and information

Information on riparian vegetation is available in two forms: maps, and assessments that consider condition. Vegetation maps showing the extent and distribution of current EVCs (ecological vegetation class) and their bioregional conservation status, current tree density and pre-1750 (modelled) distribution were downloaded from the web-site of the Department of Sustainable and Environment (17 May 2006). Riparian vegetation was mapped as part of a study of channel erosion in the upper catchment of the Ovens River (de Rose *et al.* 2005). The condition of riparian vegetation is assessed and/or discussed in the second ISC (Index of Stream Condition) (DSE 2005), the regional river strategy (North East CMA 2004), and current work by the CMA on crown frontages (Natalie Ord, pers. comm., August 2006).

This synthesis of the condition of riparian vegetation uses the following sources: vegetation maps and bio-regional conservation status (downloaded from DSE Website 14th June 2006), mapping done as part of a channel erosion study (de Rose *et al.* 2005), the ISC condition scores from the second ISC (DSE 2005), and field observations. The regional river strategy and the current work by CMA on crown frontages are not included. The regional river health strategy is not finalised, and the draft available on the web presents issues for individual reaches (the same reaches as used in the ISC) without details of condition. Current work by the CMA on crown frontages refers to very small areas only, and would be difficult to integrate into a reach-scale description:

Information on in-channel vegetation is scant. The only information located was collected as part of a survey of river condition using macro-invertebrates (Miller and Barbee 2003). That survey recorded plants that were sampled as habitat for macro-invertebrates, from sixteen sites within the study area between 1997 and 2000. Most of the sites were visited twice, once in spring and once in autumn, and there were from one to six sites per study reach. Plants were recorded only if sampled for macro-invertebrates, so the data are not survey quality. Plants were identified to genus, so no common names are given. These data indicate genera presence and differences between sites, but are of limited usefulness. No surveys were located of in-channel vegetation; in-channel vegetation is not covered by standard EVC vegetation mapping or by ISC assessments. This state of knowledge is not unusual in south-eastern Australia, where very little is known about the distribution and ecology of in-channel vegetation, especially in upland creeks and rivers.

The section on in-channel vegetation presents the plant information from the 1997-2000 survey (Miller and Barbee 2003) but relies on field observations made during the EFTP field assessment conducted in May 2006. Therefore information relates primarily to the field assessment sites.

5.1.2 Vegetation Condition

Vegetation condition can be evaluated using metrics that describe the integrity of the vegetation, its resilience and how changed it is relative to a benchmark, as exemplified by Habitat hectares (DSE 2004a) for terrestrial vegetation. The different data on riparian vegetation give understanding of condition at different spatial scales.

Two sets of information are at the landscape-scale, both describe vegetation extent, which is a useful (but simple) measure of the condition of riparian vegetation. EVC vegetation maps give a qualitative understanding of current extent through the study area and the assessments of bioregional status give an indication of how much individual EVCs have changed within a bioregion. Note that this assessment does not include EVC mosaics[1]. Also relevant at this scale is the channel erosion study (de Rose *et al.* 2005). This includes a map of the extent of woody riparian vegetation within 40 m of both sides of the channel for the whole study area (Figure 12 in de Rose *et al.* 2005). Extent here means proportion that is covered (with woody vegetation) and is mapped as five cover classes (the lowest being 0.00 to 0.20 vegetated, the highest being 0.81-1.00 vegetated) for channels between confluences. This gives finer detail on riparian cover than EVC mapping or ISC reaches. The cover classes are here referred to as: severely reduced for 0.00-0.20;

reduced for 0.21-0.40; medium cover for 0.41-0.60; good cover for 0.61-0.60; very good for 0.81-1.00.

At the reach-scale, there is the Streamside sub-index of the ISC (Index of Stream Condition) which is in two parts. The first assesses the riparian zone at a site, using width and continuity to assess how well the site is vegetated. The second assesses the condition of the riparian vegetation using a protocol that is based on Habitat-hectares (DSE 2004a), so uses several measures in three transects that extend up to 40 m from the stream at each site. For the Streamside sub-index, a field site is 430 m long, on just one side of the channel: assessments are done at three sites per reach in modified catchments. The assessments for the riparian zone and the riparian vegetation are combined into a single value for the site and three sites are averaged for the reach. The scores for the various components of condition that make up the Streamside sub-index are useful. Methods for reporting on Streamside were changed after the first ISC in 1999, and sub-index scores for the first and second ISC are not directly comparable. The second ISC in 2004 is used in this synthesis (downloaded 25th May 2006), because of its much improved method for reporting on vegetation condition.

There is currently no protocol for assessing the condition of in-channel vegetation of upland creeks and rivers in Victoria. The assessment here draws on personal experience supported by scientific knowledge (Baatrup-Pedersen *et al.* 2006, O'Hare *et al.* 2006). Condition is considered in terms of abundance, growth-forms and functional types, and nativeness of in-channel vegetation. By these criteria, the in-channel vegetation in upland streams is in 'good' condition if:

- macrophytes are sparsely and patchily distributed or even absent;
- growth-forms and functional types are biased towards those adapted to repeated disturbance by floods;
- macrophytes are native;
- there is little or no green filamentous algal growth.

5.1.2.1 Condition: Riparian vegetation

Landscape-scale

Maps of current EVC vegetation show that most of the original riparian vegetation is lost from along the valley floors in the upper Ovens River catchment and is reduced to small, discontinuous linear fragments. Riparian clearing has occurred along all the valleys in the study area, extending to where the valley begins to steepen and become hillslope. Valley clearing extends particularly

[1] "Mapping units with Bioregional conservation status and native vegetation groupings": Excel spreadsheet showing Ecological Vegetation Class (EVC) Benchmarks for each bioregion downloaded from DSE website on 14th June 2006; status is for EVCs only. mosaics and complexes are not specifically evaluated.

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high up the main stem of the Ovens River (Reach 1, cleared to about 1020 m on the West Arm), but along the other study reaches it generally ceases at about 480-660 m AHD.

Current EVC mapping does not give detail on the composition or extent of non-native vegetation, but it is evident from site inspections that the native riparian vegetation has been extensively modified or replaced by non-native species, especially willows *Salix* spp., poplars *Populus* spp. (both from the family Salicaceae) and blackberry, *Rubus fruticosus* agg.

Each of the study reaches originally had between one and three riparian EVCs (Table 5-1). The bioregional status of three of the four riparian EVCs that have been assessed is 'vulnerable', 'depleted' or 'endangered' (Table 5-1), indicating a severe reduction in extent and pointing to a loss of vegetation diversity. However, without a dedicated GIS analysis, it is not possible to determine the loss of diversity for individual reaches.

- **Table 5-1: Occurrence and bioregional status of riparian EVCs. Some EVCs occur in two bioregions within the one valley or reach. Conservation status for EVC mosaics has not been assessed. Codes for bioregions: HNF = Highlands North Fall; VR = Victorian Riverina; CVU = Central Victorian Uplands; NIS = Northen Inland Slopes.**

EVC Number & Name	18 Riparian Forest	56 Floodplain Riparian Woodland	68 Creekline Grassy Woodland	83 Swampy Riparian Woodland	84 Mosaic: Riparian Forest / Swampy Riparian Woodland / Riverine Escarpment Scrub	237 Mosaic: Riparian Forest / Swampy Riparian Woodland
Reach 1	Least Concern (HNF)			Vulnerable (HNF)		(not evaluated) (HNF)
Reach 2						(not evaluated) (HNF)
Reach 3		Vulnerable (VR)				
Reach 4						(not evaluated (HNF)
Reach 5	Least Concern (HNF) Depleted (VR)				(not evaluated) (HNF)	(not evaluated) (HNF)
Reach 6	Depleted (VR) Vulnerable (CVU)	Vulnerable (VR)				
Reach 7			Endangered (VR)			(not evaluated) (NIS)
Reach 8		Endangered	Endangered			

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		(NIS)	(VR) Endangered (NIS)			

The woody riparian cover within 40 m of the channel as mapped by de Rose et al. (2005) is summarised below (Table 5-2) for study reaches. Cover is very good for most of Reach 5 and good for most of Reach 2, but is much less in the other study reaches. Cover in Reaches 3, 6, 7 and 8 is reduced or severely reduced, and is medium in Reaches 1 and 4 (Table 5-2).

- **Table 5-2: Woody riparian cover in the environmental flow study reaches. Adapted from information presented in (de Rose *et al.* 2005).**

	Riparian Cover (proportion wooded)
Reach 1	GOOD (0.61-0.80 covered) for lower ½ of stream length; mostly MEDIUM (0.41-0.60) for upper ½ stream length
Reach 2	Mostly GOOD (0.61-0.8 covered)
Reach 3	SEVERELY REDUCED (0.00-0.20 covered) for lower 2/3 stream length; REDUCED (0.21-0.40) for upper 1/3
Reach 4	MEDIUM (0.41-0.60 covered) for about 2/3 steam length; remaining 1/3 is variable (REDUCED, GOOD)
Reach 5	MEDIUM (0.41-0.60 covered) for lowest 1/5 stream length; VERY GOOD (0.81-1.00) for upper 4/5 stream length
Reach 6	REDUCED (0.21-0.4 covered) for almost entire mapped length.
Reach 7	SEVERELY REDUCED (0.00-0.20 covered) for lower 2/3 of stream length; MEDIUM (0.41-0.60 covered) for upper 1/3 stream length
Reach 8	SEVERELY REDUCED (0.00-0.20 cover) for about 2/3 stream length; REDUCED – MEDIUM (0.21-0.6 covered) for middle section

Reach-scale

Streamside sub-index scores for ten ISC reaches occurring in the study area and collated for study reaches are summarised below (Table 5-3). The overall scores show reach condition was poor in Reach 8, good in Reaches 5 and 6 and fair to medium elsewhere (Reaches 1, 2 and 3 for the main stem and Reaches 4 and 7).

- **Table 5-3: Overall scores for Streamside sub-index in ISC_2 for 2004.**

Reach (this study)	ISC Reach Number & Name	Streamside score (max = 10)	Reach length (km)	Number of Sites
1	Reach 5: Ovens River	**5**	32	3
2	Reach 6: Ovens River	**5**	34	3
3	Reach 7: Ovens River	**5**	16	1

4	Reach 45: Morses Ck	**6**	24	1
5	Reach 43: Buckland R	**8**	17	1
	Reach 44: Buckland R	**6**	38	1
6	Reach 42: Buffalo Ck	**7**	21	3
7	Reach 41: Happy Valley Ck	**5**	31	3
8	Reach 39: Barwidgee Ck	**3**	11	3
	Reach 40: Barwidgee Ck	**3**	12	3

The overall scores are useful as a broad indicator but are a simplification as they combine the riparian zone with the riparian vegetation itself. Scores for individual components, two for riparian zone and seven for condition of vegetation, are given below (Table 5-3).

The first two components address width and continuity of the vegetated riparian zone, so are similar to the assessments of riparian cover (above), although sampled over a different sized area. Findings for the first two components are:

- **Streamside Width**: Five study reaches scored the maximum (Reaches 3, 4, 5, 6 and 7) indicating the assessed sites met benchmark values for width of native riparian vegetation. The Ovens River upstream of the Buckland River (Reaches 1 and 2) scored half the maximum, indicating less and/or variable widths. Barwidgee Creek (Reach 8) had variable streamside width, but was very poor in the lower part of the reach.
- **Longitudinal Continuity:** Only one study reach (Reach 1 – the Ovens River upstream of Morses Creek) had a high score indicating continuous riparian cover within the assessed sites, although the lower part of the Buckland River (Reach 5) also scored well. Four reaches (Reaches 2, 4, 6 and 9) and the lower part of Barwidgee Creek (Reach 8) had medium or slightly higher scores for longitudinal continuity. The Ovens River between the Buckland River and Buffalo River and the upper sections of the Buckland River and Barwidgee Creek had poor riparian longitudinal connectivity, which indicates severe fragmentation.

Table 5-4: Break-down of Streamside sub-index into nine component indicators and their scores

Study Reach	ISC Reach Number & Name	Streamside width (max 12.5)	Long. Continuity (max 12.5)	Large Trees (max 10)	Under-storey (max 25)	Recruit-ment (max 10)	Tree Canopy (max 5)	Organic Litter (max 5)	Logs (max 5)	Weeds (max 15)
1	Reach 5: Ovens R	6.25	12.5	4	8	5	2	3	2	6
2	Reach 6: Ovens R	6.25	8	4	10	5	1	4	3	8
3	Reach 7: Ovens R	12.5	3	8	5	6	0	4	0	7
4	Reach 45: Morses Ck	12.5	6	6	15	6	4	3	2	7
5	Reach 43: Buckland R	12.5	12.5	2	20	10	4	5	3	8
	Reach 44: Buckland R	12.5	3	0	15	10	2	3	2	11
6	Reach 42: Buffalo Ck	12.5	8	5	12	9	3	4	3	10
7	Reach 41: Happy Valley Ck	12.5	9	5	5	3	3	4	3	8
8	Reach 39: Barwidgee Ck	3.125	8	1	5	3	0	3	2	6
	Reach 40: Barwidgee Ck	12.5	1	3	5	3	0	0	1	8
	Number of ISC reaches scoring <50% of max	**1**	**4**	**6**	**7**	**3**	**6**	**1**	**6**	**4**

The remaining seven components describe the condition of the riparian vegetation itself.

- **Large Trees:** The number and vigour of large trees within the site (meaning those with a diameter at breast height (dbh) >=1.3 m) relative to the EVC benchmark is best in Reach 3 but scores are generally low at all ISC assessments sites and reaches. Most study reaches (Reaches 1, 2, 5, 6, 7, 8) scored poorly, with scores half or less than half the maximum; scores were very low in Reaches 5 and 8.
- **Understorey:** The understorey is assessed for its structural diversity relative to individual EVC benchmarks by considering the number of life-forms and their abundance as cover. Understorey scores are generally low, particularly in Reaches 3, 7 and 8, except in Reaches 5 and 4.
- **Recruitment**: Recruitment is scored only for native woody species. Scores are high for just two reaches, Reach 5 and 6, indicating that the number of immature stages is adequate for all the strata assessed. Recruitment is evidently poor in Reaches 7 and 8.
- **Tree Canopy**: Tree canopy is a score that combines the cover and health of canopy trees relative to the EVC benchmark. High scores were only recorded for Reach 4 and the lower part of Reach 5. Reaches 1, 2, 3 and 8 scored poorly, particularly Reach 3 and 8 which rated zero.
- **Organic litter**: Organic litter refers to the extent (as cover) and nativeness of leaves, twigs, and small fine branches on the ground. Scores for this were generally medium to good, scoring 3 to 5 out of 5. The only area with a low score for organic litter was the upper section of Barwidgee Creek.
- **Logs:** Logs compares the total length of logs >10 cm in diameter and total length of large logs (defined for each benchmark) relative to benchmark. None of the reaches scored highly, indicating a lack of large wood. The Ovens River between the Buckland River and Buffalo River (Reach 3) and Barwidgee Creek (Reach 8) had very low scores for this category.
- **Weeds:** This indicator of riparian vegetation is based on the cover of non-native species in three layers, with a high score indicating low cover; blackberry is recorded as ground cover, regardless of its height (page 20 DSE 2006b). Unlike the other indicators, there is not a wide range in scores, implying similar amounts at all assessed sites. The ISC indicates that the least weedy reaches are the Buckland River (Reach 5) and Buffalo Creek (Reach 6). The ISC does not record the identity of non-native species, so does not specifically record the presence of willows or blackberry.

Considering the study reaches individually, shows that the condition of riparian vegetation in Reach 8 (Barwidgee Creek) was generally poor, with nearly all indicators in medium to poor or very poor condition. Conversely, the riparian vegetation in the lower part of Reach 5 (Buckland River) was in better condition than other reaches, scoring well for nearly all indicators except Large Trees (Table 5-3).

Nearly all of the seven components of riparian vegetation condition are the result of land management history, disturbance or establishment of non-native species. Theoretically, river flow can be a factor in regeneration of riparian EVCs with episodic recruitment, such as EVC 56 Floodplain Riparian Woodland, which is the main riparian EVC in Reach 3, but weed competition and grazing are more likely as causes.

Site Inspections

The purpose of the site inspections was familiarisation and integration of expertise in the context of hydrology and hydraulic modelling, rather than botanical survey. Inspections also provided the opportunity to understand processes at the site scale. Field observations are included below (Table 5-5) where these add detail or complement ISC assessments of vegetation condition.

5.1.2.2 Condition: In-channel vegetation

In-channel plants sampled as habitat for macro-invertebrates as part of the Ovens River conditions project (Miller and Barbee 2003) included submerged aquatic herbs such as *Callitriche* sp, and *Potamgeton* sp., emergent macrophytes such as *Carex* sp., *Cyperus* sp., *Juncus* sp., *Phragmites* sp. and the erect herb *Persicaria* (recorded as *Polygonum*). One to two plants were recorded per site except for sites in the Ovens River between Morses Creek and the Buffalo River (Reaches 2 & 3), which had no plant habitats, and the site in Happy Valley Creek (Reach 7), which had at least four plant types.

In-channel macrophytes: field observations (May 2006)

General observations on species distributions, organised by hydraulic and geomorphic habitats, were made in May 2006 at the assessment sites within the eight study reaches, and these are summarised in Table 5-5 and Table 5-6. The observations are included here as a qualitative observational record for the CMA, and because they are the basis for the following statements on the condition of in-channel vegetation.

- **Abundance**: At most sites, the abundance (as percentage cover) was low, less than 5% of area inspected. Plants occurred as isolated patches in the stream bed, as a dense patch or near-continuous line on cobble bar or at the channel edge, or as small clumps in a backwater.
- **Species richness:** Species richness was generally low, ranging from none to three at most sites.
- **Functional Types**: Three functional types were common:
    - short-lived colonising herbs (such as the knot-weeds *Persicaria* spp.);
    - pliable perennials tolerant of flood-disturbance and of being temporarily inundated (such as the tussock sedges *Carex* spp.); and

- low-growing fine to delicate herbs in very shallow water or wet muds (such as the mudmats *Glossostigma* spp., Austral Brook lime *Gratiola* sp., and star-worts *Callitiche* spp.).

- **Nativeness**: Most sites had one of more non-native species present, but the abundance of these was always very low.

- **Table 5-5: Summary of field observations from May 2006 linking in-channel plants to habitat**

Habitat	In-channel plants
Fast flowing and shaded habitats	Very few or no in-channel aquatic plants occur where flow is fast and the channel shaded by native riparian vegetation or dense deciduous introduced species. Under tree canopies and in dappled light, shallows may sometimes support isolated clumps of amphibious species such as Watercress *Rorippa nasturtium-aquaticum*, which were observed in Morses Creek (Reach 4).
Cobble bars	Forbs and grasses establish on cobble bars, albeit temporarily. Plants were either native amphibious erect short-lived herbs characteristically found in moist soils and tolerant of temporary inundation, or perennial tussocks also tolerant of temporary inundation. Species noted were knotweeds (*Persicaria decipiens* and *Persicaria hydropiper*) and less commonly Austral Brooklime *Gratiola peruviana* and tussocks of *Carex* sp., which is a native perennial sedge. The introduced Marsh Ludwigia *Ludwigia palustris* was observed occasionally at some sites. Cobble bar communities were observed in all of the Ovens River reaches, Morses Creek and the Buckland River (i.e. Reaches 1-5).
Stable water levels	Drain Flat Sedge *Cyperus eragrostis* is an introduced summer-growing species that is typically found at the water line where water levels are stable during its growing season, such as weir pools, regulated flows or even natural pools. This species was observed in the Ovens River downstream of Morses Creek (Reaches 2 and 3).
Backwaters	Backwater habitats provide still water and favour the localised development of dense patches of small aquatic or amphibious plants such as mud-mats *Glossostigma sp*. and Swamp Crassula *Crassula helmsii* (both native) or a star-wort *Callitriche* sp. (possibly the introduced species), or even traces of submerged plants such as Charophytes. Backwater habitats and the species described here were only observed in the Buckland River (Reach 5).
Banks	Tall emergent macrophytes such as Common Reed *Phragmites australis* were uncommon in the study area. Where present they occurred in very low numbers on the banks, mostly in or close to Victorian Riverina bioregion. This might be a consequence of historical grazing pressure, but these plants are more commonly associated with lowland systems and may not have naturally occurred at high densities in the Upper Ovens River catchment. A re-vegetation guide for this area (Stelling 1994) indicates *Phragmites* should be widespread, but does not indicate how abundant. *Phragmites* was observed in the Ovens River downstream of the Buckland River and in the Buckland River.

- **Table 5-6: Summary of field observations from May 2006 – general community composition and condition.**

Community measure	Field observations
Species richness	Species richness was generally low, except in backwaters. High species richness was only observed at one field assessment site (Happy Valley Creek).

Community measure	Field observations
Biodiversity	Colonisers of cobble bars, small plants in backwaters and the small sedges and forbs in shaded banks just above the summer water line are not abundant, but are very much part of the creek and hence part of regional biodiversity.
Introduced species	Introduced species were widespread. Species noted were: Marsh Ludwigia *Ludwigia palustris*, Drain Flat-sedge *Cyperus eragrostis*, Water Couch *Paspalum distichum* , Watercress *Rorippa nasturtium-aquaticum* and possibly Common Water-starwort *Callitriche stagnalis*. None of these were abundant in May 2006. Most are widely distributed in south-east Australia, occurring commonly in channels, wetlands and riparian zones and at low levels, are unlikely to threaten system function. Most of these species are well-established in Australia with the exception of Marsh Ludwigia *Ludwigia palustris* which is a relatively recent introduction (Aston 1967).
Filamentous algae	Filamentous algae ranged from small amounts of brown (and presumably diatomaceous) biofilms to patches of green filamentous algae. Small amounts of brown biofilms were observed, mostly at riffles in all of the Ovens River sites and in the Buckland River (Reaches 1, 2, 3 and 5). Abundant and / or Green filamentous algae was observed in Happy Valley Creek and Barwidgee Creek (Reaches 7 and 8).

The combination of low-zero abundance, low species richness, a species suite dominated by the three functional types described above, low cover of non-native species and little-no growth of green filamentous algae is interpreted here as indicating generally good condition. This was evident at all field assessment sites except one. The field assessment site in Reach 7 (Happy Valley) differed from other sites in having higher abundance (in the range 5-10%) and higher species richness, in having a species suite characterised by robust emergent macrophytes (such as River Club-rush *Schoenoplectus validus*, tussocks of rush *Juncus* sp. and the introduced Drain Flat Sedge *Cyperus eragrostis*), as well as green filamentous algae. These observations suggest the in-channel vegetation at the Happy Valley Creek site is not in good condition, and is here designated as fair.

5.2 Effects or Threats of Current Flow Regime

5.2.1 State of knowledge

Ecology-flow relationships for the vegetation associated with upland creeks and rivers is not as well-known as it is for lowland rivers. There are very few ecological studies of in-channel and riparian species or plant communities for upland Australia (Entwistle 1990, Downes *et al.* 2003, Mackay *et al.* 2003). Most riparian vegetation studies in upland systems focus on their functional importance, either as a source of organic material to the stream (e.g. Thomas *et al.* 1992) or as a control of micro-climate within the channel (Davies *et al.* 2004). The few studies on individual species or communities are not relevant to the study area (eg *Casuarina cunninghamiana*, or sub-tropical streams). Because there are so few studies relevant to the study area, this description of flow regime and the likely consequences of flow changes draws on information and processes established for riparian and in-channel plant communities outside the study area (Bunn *et al.* 1998, Downes *et al.* 2003, Erskine *et al.* 2003, Baatrup-Pedersen *et al.* 2006, O'Hare *et al.* 2006).

5.2.1.1 Current flow regime

Under natural conditions, flow determines the ecology and ecological processes of in-channel and riparian vegetation in four ways.

- **Disturbance**. Disturbance is essential for maintaining the ecological character of these upland systems, through re-organising the substrate where plants grow, and through mechanical effects associated with velocity such as scouring, breakage and removal of plant parts or whole plants. This kind of disturbance is an ecological re-setting mechanism that is followed by colonisation and re-establishment of species and gradual build up of biomass. Disturbance includes large flow events, such as floods, as well as small events such as freshes.
- **Transporting agent.** Flow removes organic material and litter, exposing the soil surface and so creating a regenerating opportunity and carries it downstream. Moderate to large flows can pick up plant propagules (seeds, and specialised structures and vegetative parts) and transport them to new sites downstream.
- **Habitat for in-channel plants.** All aquatic and some amphibious plants are not protected against desiccation and many do not have strong supportive tissues to hold the plant upright. Growing in water provides support and protects these plants against desiccation.
- **Essential resource.** All plants require water, to grow and to survive. Trees in the riparian zone obtain their water from different sources, depending on species and position relative to the channel. Trees next to the stream are likely to use stream water; those further away probably use ground water. Some species can switch between different sources.

Modifications to the flow regime change these relationships and dependencies. Some examples follow. Removing small summer freshes results in extended periods of flows with little or no disturbance, which are ideal conditions for the accumulation and growth of filamentous and benthic algae, especially in streams that are un-shaded (i.e. not light limited) and have high nutrient concentrations. Lowering summer flows to the point of routinely having no surface flow for several weeks changes the availability of flow as a resource to riparian vegetation and some in-channel vegetation, and habitat for in-channel plants. Stresses produced by reduced summer flows are unlikely to kill the riparian vegetation in one season (unless very prolonged, and combined with very hot conditions) but the cumulative effects on vigour could over time be expected to change the character of the riparian vegetation and facilitate a transition to more terrestrial plant communities.

5.3 Reach Summary

The condition of the riparian and in-channel vegetation, current issues and threats and general flow recommendations are summarised below (Table 5-7) for each reach. This summary is based on information presented in the preceding section and observations at field assessment sites. Because riparian cover is given in detail by de Rose et al. (2005), the ISC assessments for Width and Longitudinal Continuity of the riparian zone are not included.

The principal points (already recognised in the Regional River Health Strategy (North East CMA 2005)) are: the extent of the native vegetated riparian zone has been considerably reduced, both laterally and longitudinally, leaving fragmented small patches; there are very few areas of extensive high quality native riparian vegetation within the study reaches, and instead the condition is generally poor. Because the riparian zone influences in-channel processes, this reduction in extent and condition has implications for river health. It also gives the remaining riparian vegetation, of all conditions, a particular ecological significance and value, and protection of this should be a priority.

The reduced extent of the riparian zone has more to do with land management than flow. The long history of European settlement in the study reaches means riparian vegetation has been cleared to provide residential space and agricultural purposes and has also been being cleared and disturbed through gold mining activities. Reasons for the poor condition of the riparian vegetation are largely to do with a history of utilisation (removal large trees, fallen logs), stock access (modification of understorey, weed transport), and the extensive presence of dominating introduced species within the riparian zone, as well as deliberate plantings. Some riparian patches may be re-growth that has not yet developed the characteristics of an 'old' community. River flow is likely a factor in the downstream dispersal of riparian species including unwanted introduced species such as willows and (to a lesser extent) blackberry. It is probably also a factor in dispersing introduced in-channel plants.

- **Table 5-7: Summary of condition, issues and threats and flow related objectives for vegetation in the upper Ovens River study area.**

Reach	Vegetation issues
Reach 1: Ovens River. From above Harrietville to Morses Creek confluence	**Condition** **Riparian Vegetation** ▪ Reduced in extent in the valley, and reduced in diversity (EVC mapping & bioregional status); good to medium cover, with more in lower parts of study reach (de Rose *et al.* 2005) ▪ Medium (5/10) for Streamside sub-index, but rating poorly for Tree Canopy, Logs and Weed. ▪ FIELD SITE: Native vegetation, all strata present but willows and blackberries present; willow encroachment into the channel was evident. **In-channel vegetation** ▪ FIELD SITE: Good at field site. **Issues & Threats** ▪ Actively maintain extent and quality of existing riparian vegetation **Flow Objectives** ▪ In-channel & Riparian: Preserve natural disturbance regime

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Reach	Vegetation issues
	▪ In-channel & Riparian: Avoid long-low flow periods
Reach 2: Ovens River. From Morses Creek confluence to Buckland River confluence	**Condition** **Riparian Vegetation** ▪ Reduced in extent and diversity (EVC mapping & bioregional status) along valley; riparian cover mostly good (de Rose *et al.* 2005) ▪ Medium (5/10) for Streamside sub-index, with medium scores for all components except Organic Litter which is high, and Tree Canopy which is poor. ▪ FIELD SITE: Patches of native and non-native vegetation, Blackberries present; drier areas with urban and garden weeds such as cotoneaster. **In-channel vegetation** ▪ FIELD SITE: Good at field site **Issues & Threats** ▪ Vigilance needed in relation to 'urban' and garden weeds **Flow Objectives** ▪ In-channel & Riparian: Preserve natural disturbance regime ▪ In-channel & Riparian: Avoid long low-flow periods
Reach 3: Ovens River. From Buckland River confluence to Buffalo River confluence	**Condition** **Riparian Vegetation** ▪ Severely reduced in extent within study reach (EVC mapping); riparian cover reduced or severely reduced (de Rose *et al.* 2005). ▪ Medium (5/10) for Streamside sub-index, scoring highly for Organic Litter, but poorly for Understorey structural diversity, Tree Canopy and Logs. ▪ FIELD SITE: Riparian vegetation confined to within channel, mix of native and non-native components; dense blackberries on steep bank, well-established willows on inside bend; willows stabilising cobble bars. **In-channel vegetation** ▪ FIELD SITE: Good at field site **Issues & Threats** ▪ Riparian zone highly altered relative to natural (extent, condition, exotics, openness) so not fulfilling its ecological role in relation to river health ▪ Willows **Flow Objectives** ▪ In-channel & Riparian: Preserve natural disturbance regime ▪ In-channel & Riparian: Avoid long low-flow periods
Reach 4: Morses Creek	**Condition** **Riparian Vegetation** ▪ Reduced in extent along valley (EVC mapping); riparian cover is mostly medium but variable (de Rose *et al.* 2005) ▪ Medium (6/10) for Streamside sub-index, scoring highly for Understorey and Tree Canopy but poorly for Logs. ▪ FIELD SITE: Native overstorey and shading stream, dense blackberries in understorey. **In-channel vegetation** ▪ FIELD SITE: Good at field site **Issues& Threats**

Reach	Vegetation issues
	▪ Maintain extent and quality of existing riparian vegetation ▪ Urban and agricultural impacts on remaining vegetation ▪ Rehabilitation needed for riparian zone that is in parts dominated by exotics and highly disturbed **Flow Objectives** ▪ In-channel & Riparian: Preserve natural disturbance regime ▪ In-channel & Riparian: Avoid long low-flow periods
Reach 5: Buckland River	**Condition** **Riparian Vegetation** ▪ Reduced in extent and diversity (EVC mapping & bioregional status); riparian cover is mostly very good (de Rose *et al.* 2005) ▪ Dominance of non-native ground cover ▪ Medium-good (8/10 and 6/10 for ISC reaches) for ISC Streamside sub-index, scoring very highly for Recruitment and very poorly for Large Trees along both ISC Reaches within study reach. Lower part (ISC Reach 43) of Buckland River rated highly for Understorey structural diversity, Tree Canopy and Organic Litter. Upper part (Reach 44) does score highly for lack of Weeds. ▪ FIELD SITE: Left steeper bank with native vegetation, all strata and high diversity; Dense blackberries on right bank and trailing down face of bank; sparse willows. **In-channel vegetation In-channel vegetation** ▪ FIELD SITE: Good at field site. **Issues & Threats** ▪ Maintain extent and quality of existing riparian vegetation ▪ Agricultural activities encroaching on remaining vegetation ▪ Control of exotic species and re-planting of native species **Flow Objectives** ▪ In-channel & Riparian: Preserve natural disturbance regime ▪ In-channel & Riparian: Avoid long low-flow periods
Reach 6: Buffalo Creek	**Condition** **Riparian Vegetation** ▪ Reduced in extent and diversity (EVC mapping & bioregional status); riparian cover is reduced along most of channel (de Rose *et al.* 2005) ▪ Medium-good (7/10) for Streamside sub-index , scoring highly for Recruitment, Organic Litter and Weeds. ▪ FIELD SITE: Overstorey remnant shrubs and fine old tree, understorey shrubby plus dense blackberries on both banks, arching over channel. **In-channel vegetation** ▪ FIELD SITE: Absent at field site. **Issues & Threats** ▪ Actively protect extent and quality of existing riparian vegetation ▪ Control of exotic dominant species, with re-planting **Flow Objectives** ▪ In-channel & Riparian: Preserve natural disturbance regime ▪ In-channel & Riparian: Avoid long low-flow periods
Reach 7:	**Condition**

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Reach	Vegetation issues
Happy Valley Creek	**Riparian Vegetation** ▪ Reduced in extent and diversity (EVC mapping & bioregional status); riparian cover is severely reduced for most of lower part of reach and medium further upstream (de Rose *et al.* 2005). ▪ Medium score (5/10) for ISC Streamside sub-index, scoring well for Organic Litter but very poorly for Understorey structure and Recruitment. ▪ FIELD SITE: Evidence of past efforts at control of large well established willows. Understorey is introduced grasses; no shrub layer. **In-channel vegetation** ▪ FIELD SITE: Fair at field site. **Issues & Threats** ▪ Riparian zone highly altered relative to natural (extent, condition, exotics, openness) so not fulfilling its ecological role in relation to river health ▪ Enhance risk of nuisance growths in-channel due to lack of riparian shade and higher nutrients ▪ Continue program of exotic control, encourage re-planting of appropriate native species **Flow Objectives** ▪ In-channel & Riparian: Preserve natural disturbance regime ▪ In-channel & Riparian: Avoid long low-flow periods
Reach 8: Barwidgee Creek	**Condition** **Riparian Vegetation** ▪ Reduced in extent and diversity (EVC mapping & bioregional status); riparian cover is severely reduced for most of stream length (de Rose *et al.* 2005). ▪ FIELD SITE: dense canopy of willows, arching over channel: understorey where present is introduced grasses. Natïve riparian vegetation virtually absent. **In-channel vegetation In-channel vegetation** ▪ FIELD SITE: Good at field site. **Issues & Threats** ▪ Riparian zone highly altered relative to natural (extent, condition, exotics, openness) so not fulfilling its ecological role in relation to river health ▪ Lack of riparian shade and high nutrients enhance risk of nuisance growths in-channel ▪ Continue program of exotic control, encourage re-planting of appropriate native species **Flow Objectives** ▪ In-channel & Riparian: Preserve natural disturbance regime ▪ In-channel & Riparian: Avoid long low-flow periods

5.4 General Management Considerations

5.4.1 Riparian Vegetation

The principal issues and threats to riparian vegetation in the study area are to do with historic and on-going land management. The effect of these on riparian vegetation and then in turn on stream health is a fine example of how adjacent land management affects the in-stream environment. The issues and threats can be distilled down to the extent of the riparian zone and the dominance of the riparian zone by two exotic species. These land management issues are already factored into the Regional River Health Strategy (North East CMA 2004).

5.4.1.1 Extent of Riparian zone

Extent of the native riparian zone, meaning its width and density, has been greatly reduced through clearing. Although this is evident on maps and on the ground, the extent of fragmentation would be worth quantifying through a GIS analysis using standard landscape metrics to describe size, fragmentation and isolation. Such an analysis could facilitate prioritisation of effort for rehabilitation. The reduction in native riparian zone is an important issue for stream health as it has direct effects on the in-channel environment and bank stability and provides an opportunity for undesirable species to establish. It also means a gross reduction in inputs of organic material such as leaves of native trees into the stream.

In areas that are cleared or have very low riparian cover, the in-channel environment is continuously unprotected from solar radiance, which has implications for river health (Davies *et al.* 2004). As a result of being exposed, the water in the stream heats up, the oxygen capacity of the water is lowered and respiration increases. The net effect is an increased demand on in-channel oxygen, such that anoxia can result. It is also possible for water temperatures to increase to the point that the thermal tolerances of aquatic insects are exceeded (Davies *et al.* 2004). Extra irradiance can encourage plant growth in-channel (e.g. Bunn *et al.* 1998). If this happens, then the stream character is in danger of changing from heterotrophic (the natural condition for upland streams) to autotrophic.

Clearing the adjacent vegetation also encourages other behaviours or activities that in turn diminish the buffering value of the riparian zone. The lack of a buffer adjacent to the riparian zone, for example, makes it easier for stock, people and vehicles to enter and trample down riparian vegetation. Bank stability may be affected if the adjacent vegetation is cleared away through allowing vehicles and machinery to the top of the bank.

Re-planting is clearly an important remedy for this and a strategic approach could prove useful for maximising returns relative to effort. For example re-planting efforts should focus on connecting existing remnants or increasing the riparian zone width on certain bends. Single-line plantings provide some shade for the channel but are too narrow to be effective as a riparian zone.

5.4.1.2 Weeds

The scores for Weeds component in the Streamside sub-index of the ISC (Table 5-4) are between 6 and 8 out of 15 for all reaches except Reach 5 and 6, suggesting that weediness is a common riparian issue in the study area. This was certainly the impression gained through field inspection in May 2006 (Table 5-6). The ISC is a rapid appraisal so does not attempt to record species identity, thus although these scores are low it is not possible to determine from archived data which species are problematic. Despite not being quantified or specifically mapped, it is clear from discussions with the CMA and from travelling between field assessment sites that the two major riparian weeds are willows and blackberry.

Willows, *Salix* sp. in the family Salicaceae, are a group of non-native tree species, which have the potential to impact negatively on in-stream health and channel morphology. Three species were noted during the field inspections: Weeping willow (*Salix babylonica*), the self-seeding Pussy willow (*Salix cinerea*), and crack willow *Salix fragili.* Black willow (*Salix nigra*) is also known to occur in the study area (Matthew O'Connell Environmental Water Resources Officer North East CMA pers. Comm.).

Willows are a problem for river managers for several reasons. Compared with native Australian trees, the leaves of introduced deciduous trees such as willows fall at a different time of year and break-down much more rapidly, and this alters the in-stream productivity patterns (Schulze and Walker 1997). Willows can establish from seed or twigs in a relatively small space but grow to occupy a large space, thus willows displace native species through shading and root competition. Willows also have a geomorphic role (already mentioned) and it was clear from the field inspection that this is also a major issue in the study area. Willows influence channel development in two ways. First they stabilise cobble bars and benches within the channel, facilitating the establishment of native species such as *Eucalyptus camaldulensis* and *Callistemon* sp. Second, willows block channels and causing blow-outs (as evident in Barwidgee Creek). Willows have flexible branches and the capacity to regenerate from fragments, which make them well-adapted to the flow disturbance regime of the rivers where they originate. However, these same characteristics make willows a pest species wherever they are introduced (Kerrenberg *et al.* 2002). Poplars are in the same family as willows (Salicaceae) and share many of the same characteristics.

No mapping of willows (or blackberry) infestations were located. Such mapping, if available, would make it feasible to compare the severity of infestations between reaches and could help establish priorities for control. Field sites certainly differed in what weed species occurred there, and how abundantly but it is unwise to extrapolate from field sites to the whole reach. Willow sawfly may have some effect on the vigour of willow stands in the near future (Ede 2006), but river managers will still need a willow program for removal of stumps and trees.

5.4.2 In-channel vegetation

Hydrological disturbance is important in keeping abundances low, in re-distributing species or dispersing propagules, and in maintaining in-channel vegetation at an early stage. The observations made at the field assessment sites in May 2006 did not suggest major issues for in-channel vegetation. Although a number of species noted were not native, most of these are common in Victorian streams and are not recognised as posing major threats, provided (as stated above) conditions favourable for developing excessive growths are avoided. One species, Marsh Ludwigia *Ludwigia palustris* may have potential to be problematic downstream (Aston 1967).

6. Fish

6.1 Background and condition

Nine native fish species and nine exotic species have been recorded on the Department of Sustainability and Environment (DSE) flora and fauna database (DSE 2006a) from the Ovens River study area and tributaries since 1948 (Table 6-1). Prior to European settlement seven native fish species were predicted to occur in the upper Ovens River and tributaries (equivalent to Reaches 1, 2, 4 and 5) and 13 species were predicted in the mid reaches (equivalent to Reaches 3, 6, 7 and 8); an additional 5 species were predicted to be present in the lower reaches downstream of Wangaratta (MDBC 2004a and see Table 6-2).

The most widespread and abundant native species currently present in the study area are two-spined blackfish *Gadopsis bispinosus*, river blackfish *Gadopsis marmoratus* and mountain galaxias *Galaxias olidus*. There are recent records of Murray cod *Maccullochella peelii peelii* from the Buckland River and the Ovens River around Myrtleford; historical records indicate they where present as far upstream as Bright, although this was likely to represent the upper limit of their natural distribution. Trout cod *Maccullochella macquariensis* have also been recently recorded in the Ovens River around Myrtleford; they have been stocked extensively in lower reaches and also in the Buffalo River upstream of Lake Buffalo. Where present in the study area both Murray cod and trout cod exhibit low abundance although they are present in higher numbers in the Ovens River downstream of Myrtleford. Less common species recorded in the study area include, southern pygmy perch *Nannoperca australis*, Australian smelt *Retropinna semoni* and common galaxias *Galaxias maculatus*, the later is a diadromous species that requires access to the sea, although landlocked populations have been recorded in some southern parts of the Murray-Darling Basin.

Trout cod, Murray cod and Macquarie perch are considered threatened in Victoria and Australia and are listed under the Victorian Flora and Faun Guarantee Act 1988 and the commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (DSE 2003a). Mountain galaxias is data deficient with respect to its conservation status in Victoria; other species are not considered threatened (DSE 2003a).

The most abundant exotic species are brown trout *Salmo trutta* and rainbow trout *Oncorhynchus mykiss*. Redfin perch *Perca fluviatilis* are widespread but in low abundance. Carp *Cyprinus carpio,* goldfish *Carassius auratus*, oriental weatherloach *Misgurnus anguillicaudatus*, tench *Tinca tinca* and chinnok salmon *Oncorhynchus tshawytscha* have also been recorded, the later most likely a fish farm escapee.

Trout have been recorded in the Ovens River system from as early as 1948 (DSE 2006a) and are an important social asset for recreational fishing in most reaches. Brown trout were routinely stocked in the Ovens and Buckland Rivers until the mid 1990s and were recently stocked in the Buckland River to assist in the post 2003 bushfire recovery of trout populations (DPI 2006). However, predation by trout may pose a threat to small native fish such as mountain galaxias and southern pygmy perch (Closs and Lake 1996).

Other exotic fish species also pose threats to the native fish community and more broadly to riverine ecology in general. For example, redfin perch may also predate on native species while carp may compete for habitat and food resources (Cadwallader 1978).

Prior to European settlement Macquarie perch *Macquaria australasica* were predicted to have been widespread through the Ovens River, including the upper reaches in the study area (Cadwallader 1981, MDBC 2004a). Macquarie perch have been recorded in the Buckland River (Reach 5) although the record is undated (DSE 2006a) and it is unlikely that they currently exist in this river. However, they are currently present in the adjacent Buffalo River and its main tributaries the Rose and Dandongadale Rivers (Lyon 2006). There are no recent records of Macquarie perch from the Ovens River main stem; habitat destruction, competition from redfin perch and dam construction (eg. Lake Buffalo) are thought to be the major factors contributing to the decline of Macquarie perch in the basin (Lyon 2006). Macquarie perch were stocked in the Buffalo River in large numbers (>60,000) in the early 1990s to bolster the remnant population in that river upstream of Lake Buffalo (Lyon 2006). Recent surveys suggest that the current Buffalo River population has low abundance but there is evidence of spawning and successful recruitment (Lyon 2006). As this population is upstream of Lake Buffalo there is limited opportunity for movement and dispersal to downstream reaches, including the Ovens River main stem. Active stocking would be required to re-establish Macquarie perch elsewhere in the Ovens River system.

Trout cod were also predicted to naturally occur in the upper Ovens River (MDBC 2004a). Loss of habitat through extensive mining and dredging of the river system in the early 1900s and the 1950s drought are thought to have contributed to the local extinction of trout cod in the Ovens River catchment (SKM 2001a). Barriers to fish passage are also likely to restrict opportunities for recolonisation from lower reaches. Over the past fifteen years trout cod have been extensively stocked in the lower Ovens River downstream of Wangaratta (from 1996 to date) and in the Buffalo and Rose Rivers upstream of Lake Buffalo (from 1992 to 1995) (DPI 2006). Within the study area they have been stocked in Buffalo Creek (from 1990 to 1993) and more recently in the Buckland River (2004) (SKM 2001a, DPI 2006). Recent surveys and unsubstantiated recreational fishing reports indicate trout cod are now occasionally encountered in the mid and upper Ovens River and the Buckland River. Unimpeded fish passage between the lower and upper Ovens River is required to ensure opportunities for expansion of trout cod from their core location in the lower Ovens River to upstream reaches.

The lower Ovens River currently supports one of the most significant Murray cod populations in Victoria (Cottingham *et al.* 2001). Although they are predicted to have occurred more widely throughout the Ovens system (MDBC 2004a), they are currently recorded in only low numbers in the mid reaches and the last record from the upper reaches (Reach 2) is from 1948. Habitat degradation and restricted fish passage (eg. barriers in the Ovens River at Tea Garden Creek, Porpunkah and Bright) may have contributed to the decline in distribution and abundance of Murray cod in the mid and upper reaches.

Golden perch are also present in the Ovens River downstream of Wangaratta (DSE 2006a) and in the Buffalo River downstream of Lake Buffalo (Lyons 2006) but have not been recorded in the study area. They are predicted to have been present in the lower reaches of the study area (Reach 3) (MDBC 2004a) but the upper reaches (Reaches 1, 2 and 5) are likely to be outside the natural range of this species. As with Murray cod and trout cod, habitat degradation and barriers to fish passage (particularly at Tea Garden Creek) may have contributed to their absence in the mid reaches of the Ovens River, effectively preventing populations in the lower Ovens River from migrating to the mid and upper reaches from time to time.

Of the smaller tributary stream reaches two-spined blackfish, river blackfish and mountain galaxias have been recorded in Morses Creek, Buffalo Creek and Happy Valley Creek. Mountain galaxias have been recorded in Buffalo Creek and Happy Valley Creek and southern pygmy perch have been recorded from Happy Valley Creek. Historical records (prior to 1981) from Barwidgee Creek reported river blackfish, trout and redfin perch. Anecdotal recreational fishing reports indicate that brown trout and rainbow trout are currently present in Barwidgee Creek. Interestingly, 9900 trout cod were stocked in Buffalo Creek from 1990 to 1993 (Barnham 1998), but there is no evidence of their subsequent presence in the creek.

Climbing galaxias *Galaxias brevipinnis* are a native species from coastal streams that have established populations in some tributaries of the Murray River upstream of Lake Hume as a result of unintended translocation via transfers of water from the Snowy River (Morrison and Anderson 1991). However, they appear to now be expanding their range downstream and have been recorded in the Ovens River catchment, specifically in the King River (Lyon 2006) but not in the study area. According to Waters *et al.* (2002) there is a risk of hybridisation between translocated climbing galaxias and mountain galaxias, although there is no evidence that such hybridisation has occurred. There is also a risk that due to the climbing ability of climbing galaxias that they may colonise streams above waterfalls that are currently fish-free (Waters *et al.* 2002). Environmental objectives and flow recommendations for the Ovens River are unlikely to promote the spread of climbing galaxias. However, future studies are needed to monitor any expansion in their distribution.

- **Table 6-1 Fish recorded from the upper Ovens River and tributaries since 1948. Ticks indicate relative abundance for species recorded in the past twenty years (✓ present, ✓✓ common, ✓✓✓ abundant). Date of last record is provided for species last recorded more than 20 years ago. (Source: MDBC 2004a, DSE 2006a, Lyon 2006).**

Scientific name	**Common name**	Conser-vation status (DSE 2003a)		Reach 1 Ovens Rv: us Morses C	Reach 2 Ovens Rv: Morses C - Buckland R	Reach 3 Ovens Rv: Buckland R - Buffalo R	Reach 4 Morses Ck	Reach 5 Buckland Rv	Reach 6 Buffalo Ck	Reach 7 Happy Valley	Reach 8 Barwidgee
Native		**Vic**	**Aus**								
Gadopsis bispinosus	Two-spined Blackfish			✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓	
Gadopsis marmoratus	River Blackfish					✓✓		✓(1983)	✓	✓(1986)	✓ (1981)
Galaxias maculatus	Common Galaxias			✓(1980)		✓(1980)		✓(1980)	✓		
Galaxias olidus	Mountain Galaxias	DD			✓✓✓	✓✓✓		✓✓	✓✓	✓	
Maccullochella macquariensis	Trout Cod	CR L	EN			✓ (ds of reach)			Stocked (1990-1993)		
Maccullochella peelii peelii	Murray Cod	EN L	VU		✓(1948)	✓		✓			
Macquaria australasica	Macquarie Perch	EN L	EN					✓ (undated)			
Nannoperca australis	Southern Pygmy Perch					✓		✓(1980)		✓	
Retropinna semoni	Australian Smelt					✓			✓ (1980)		
Exotic		No conservation status									
Carassius auratus	Goldfish					✓(1983)				✓ (1986)	
Cyprinus carpio	Carp					✓					
Gambusia holbrooki	Gambusia					✓					
Misgurnus anguillicaudatus	Oriental weatherloach						✓(1982)				
Oncorhynchus mykiss	Rainbow trout			✓✓	✓✓	✓✓	✓	✓✓	✓✓		✓ (1981)
Oncorhynchus tshawytscha	Chinook salmon			✓(1985)							
Perca fluviatilis	Redfin perch			✓(1980)	✓(1985)	✓	✓(1979)	✓(1984)		✓(1986)	✓ (1981)

Scientific name	Common name	Conser-vation status (DSE 2003a)	Reach 1 Ovens Rv: us Morses C	Reach 2 Ovens Rv: Morses C - Buckland R	Reach 3 Ovens Rv: Buckland R - Buffalo R	Reach 4 Morses Ck	Reach 5 Buckland Rv	Reach 6 Buffalo Ck	Reach 7 Happy Valley	Reach 8 Barwidgee
Salmo trutta	Brown trout		✓✓	✓✓	✓✓	✓	✓✓	✓	✓	✓ (1981)
Tinca tinca	Tench		✓(1948)							

Vic – Victorian Conservation Status DD=data deficient, CR=Critically endangered, EN=Endangered, L=listed under Victorian *Flora and fauna Guarantee Act 1988*

Aus –Conservation Status in Australia, listed under the *Environment Protection and Biodiversity Conservation Act 1999* as Endangered (EN) or Vulnerable (VU)

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- **Table 6-2 Native species predicted to occur in the Ovens River prior to European settlement (Source: MDBC 2004a).**

Scientific name	Common Name	Source Zone *Upper Ovens & Buckland Rv* *(Reaches 1, 2, 4, 5)*	Transport *Mid Ovens Rv & rural tribs* *(Reaches 3, 6, 7, 8)*	Deposition *Lower Ovens Rv (downstream study area)*
Bidyanus bidyanus	Silver Perch		+	+++
Craterocephalus stercusmuscarum fulvus	Fly-specked Hardyhead			+++
Gadopsis bispinosus	Two-spined Blackfish	+++	+++	
Gadopsis marmoratus	River Blackfish	+	+++	+++++
Galaxias olidus	Mountain Galaxias	+++++	+++	+
Galaxias rostratus	Flat-headed Galaxias		+++	+++
Hypseleotris klunzigeri	Western Carp Gudgeon		+++	+++++
Maccullochella macquariensis	Trout Cod	+	+++	+++++
Maccullochella peelii peelii	Murray Cod		+++++	+++++
Macquaria ambigua	Golden Perch		+++	+++++
Macquaria australasica	Macquarie Perch	+++	+++++	+++++
Melanotaenia fluviatilis	Murray-Darling Rainbowfish			+++
Mogurnda adspersa	Southern Purple-spotted Gudgeon			+++
Nematalosa australis	Bony Bream			+
Nannoperca australis	Southern Pygmy Perch	+	+++	+++
Philypnodon grandiceps	Flat-headed Gudgeon		+++	+++
Retropinna semoni	Australian Smelt	+	+++++	+++++
Tandanus tandanus	Freshwater Catfish			+

0	Not predicted to occur
+	Predicted to have been rare (expected to occur on <20% of sampling occasions
+++	Predicted to have usually occurred (21-70% of sampling occasions)
+++++	Predicted to have almost invariably occurred (71-100% of sampling occasions)

The Murray Darling Basin Commission Sustainable River Audit (SRA) fish theme pilot study has been recently completed in the Ovens River (MDBC 2004a). A number of indices of fish community health were determined including *Expected species richness* (proportion of current native species compared to expected native species) and *Nativeness* (proportion of native to exotic species). Scores are expressed from 0 to 1 with 1 indicating equivalent to natural or reference condition and 0 indicating extreme modification from natural or reference condition. In the Upper Ovens, or source zone, the expected species richness scores ranged from 0.4 to 0.7 with an average score of 0.43 and the nativeness score ranged from 0.18 to 0.35 with an average of 0.32, both scores indicating major modification compared to natural or reference condition (Table 6-3). The particularly poor nativeness score can be attributed to the relatively low number of native species compared to a high number of exotics, namely brown and rainbow trout, carp and redfin. In the mid Ovens or Transport zone the expected species richness ranged from 0.35 to 0.52 and averaged 0.37 indicating major modification while the nativeness score ranged from 0.3 to 0.9 and averaged 0.83 indicating minor modification (Table 6-3). The improvement in nativeness scores in the mid-reaches can be attributed to an increased number of native species being present, namely Murray cod and trout cod. Further downstream the species richness and nativeness scores remain relatively poor, indicative of a majorly modified system with respect to fish community composition.

- **Table 6-3 SRA pilot fish theme fish community health scores for the Ovens River (MDBC 2004a).**

Fish community health indicators	**Source Zone** *Upper Ovens & Buckland Rv* *(Reaches 1, 2, 4, 8)*	**Transport** *Mid Ovens Rv & rural tribs* *(Reaches 3, 5, 6, 7)*	**Deposition** *Lower Ovens Rv (downstream study area)*
Expected species richness	0.43	0.37	0.34
Nativeness	0.32	0.83	0.36

It should be noted that the SRA audit was based on a single sampling occasion at seven sites in each zone that don't necessarily match with the environmental flow sites. In other words the SRA assessment provides a broad scale basin assessment rather than a reach specific assessment of fish community health. Even so, the results indicate that the overall condition of the native fish community in the Ovens River is poor or moderate at best. Despite this, the Ovens River, and the mid and lower Ovens in particular does provide significant habitat for native fish and contains significant populations of several threatened species, namely Murray cod, trout cod and Macquarie perch. Management actions must be aimed at sustaining and improving conditions for these species.

6.2 Flow requirements and flow regime impacts

While all fish have a dependency on water, various species may be more or less reliant on particular components of the flow regime at various stages in their life cycles (Table 6-4). The larger species (ie Murray cod, Trout cod and Macquarie perch) require deep pool habitat (typically >1 m) with abundant cover from boulders and large woody debris (eg. Koehn and O'Connor 1990, Harris and Rowland 1996). The smaller river and two-spined blackfish also require abundant instream cover but prefer shallower pools (10-50 cm deep) and slow velocity (<20 cm/s) (eg. Koehn *et al.* 1994, Curmi 1996, Khan *et al.* 2004).

All species present require opportunities for dispersal movement, although river and two-spined blackfish in particular have very small home ranges (typically <25 m) with high site fidelity and may spend their entire lives in a single pool without need for wide scale dispersal movement (eg. Koehn 1986, Lintermans 1998, Khan *et al.* 2004).

Golden perch and some Murray cod individuals undertake an upstream migration during the spawning period in spring and early summer but a rising water level is not necessarily a trigger of such movement with movement occurring in flood and non-flood years in the lower Ovens River (Koehn 1996). Migration is also not a prerequisite for spawning with larvae of both golden perch, and Murray cod detected in flood and non-flood years in the Broken River (Humphries *et al.* 2002). Although an increased flow is not necessarily a movement trigger it may help in the provision of passage through shallow riffles and over other instream barriers and may help in the downstream dispersal of eggs and larvae through drift and in both upstream and downstream dispersal movement of juveniles and adults (Humphries *et al.* 2002). Floods that coincide with spawning may also enhance larval survival and recruitment through to adults by triggering a pulse of zooplankton productivity that provides an important food resource for larvae and juveniles of most native species (Humphries *et al.* 2002).

Riverine populations of Macquarie perch do not undertake a specific spawning migration, although lake populations will move into tributary streams to spawn (Cadwallader and Rogan 1977). While increased flow does not seem to be a trigger for migration or spawning; increased temperature and photoperiod being more likely (Appleford *et al.* 1998), an increased flow prior to and during the spawning season may help flush spawning riffles of accumulated sediment and maintain a flow of well oxygenated water over eggs lodged in riffles (Cadwallader 1981). In the Ovens River Macquarie perch are restricted to the Buffalo River upstream of Lake Buffalo. Future management activities should be aimed at strengthening the Buffalo River population prior to efforts to expand the population into other parts of the catchment. Although no objectives for the rehabilitation of Macquarie perch in the study area reaches will be specified, flow recommendations will not preclude the re-establishment of populations in the future. If a future management decision is made to re-establish Macquarie perch in the study area, the Buckland River (Reach 5) is likely to offer the greatest potential for rehabilitation.

Australian smelt larvae and juveniles may undertake an upstream dispersal movement during small water level rises (Mallen-Cooper 1994), but it would appear that such movement is not critical to the survival of the species, it being one of the most abundant and widespread species in the Murray-Darling Basin.

Although there are few specific flow requirements or flow components that trigger various life history stages in native fish recorded from the study area, permanent flow is required by all species. A suitable low flow is required year round to maintain sufficient pool depth for all species, but particularly for river and two-spined blackfish and the larger Murray cod and trout cod. While not a specific requirement to trigger movement or spawning, higher flows in winter and spring may facilitate movement of Murray cod, trout cod and golden perch. High flows at this time may also facilitate the downstream dispersal of drifting larvae of these species and floods may provide a pulse of zooplankton productivity that enhances larval fish survival.

The specific flow regime impacts in the study area are likely to occur in the summer and autumn period when diversions result in a decrease in the summer low flow. As indicated above, the maintenance of permanent flow and suitable pool depth during low flow periods are key requirements for all species. Occasional freshes are also needed to flush pools and prevent flow related declines in water quality, particularly decreases in dissolved oxygen than can occur in pools during prolonged low flow periods.

Under current conditions natural seasonality is maintained so winter and spring high flows are unlikely to have been affected to such an extent that they limit opportunities for movement (except where barriers are present). However, it is important that these components are protected in to the future.

Loss of large woody debris habitat, barriers to movement and the presence of exotic species are likely to have a greater impact on the native fish community in the upper Ovens River than specific flow impacts. The provision of suitable flow and habitat for native fish is unlikely to disadvantage exotic species, however, native fish will be better able to compete with exotic species if preferred conditions are available.

SKM

- **Table 6-4 Summary of habitat requirements and flow dependency for native fish recorded in the study area (Source: Review of habitat association by SKM 2003).**

Common Name	Adult habitat	Adult movement	Larval habitat	Specific flow dependency
River Blackfish	Slow flowing pools with abundant cover, in particular, LWD.	Local movement limited to home range of 25-30 m	Benthic substrates (silt/detritus)	Requires perennial flow with pools depths 20-50 cm. Requires flow over spawning site (0.1-0.2 cm/s) to prevent siltation.
Two-spined Blackfish	Cool clear waters; prefers areas of adequate cover away from open water.	Sedentary with home range of ~15 m	Leaf litter & LWD on edge of still sections of streams.	Likely to be similar to river blackfish.
Mountain Galaxias	Streams with fringing & overhanging vegetation.	Possible short upstream movement.	Form loose shoals in pools & may disperse downstream	Adults can survive in isolated pools during summer. Eggs layed in fast flowing riffles (0.2-0.5 m/s).
Southern Pygmy Perch	Still & slow flowing water in creeks, wetlands & backwaters of large rivers amongst dense submerged macrophytes.	Local movement only	Shallow still waters amongst macrophytes	Perennial flow / wetlands. No specific flow dependency.
Murray Cod	Deep holes with high levels of cover such as rocks, fallen trees, stumps, clay banks or overhanging vegetation. Distinct preference for high densities of LWD	Some individuals migrate upstream in late winter/spring to spawn. Migration may be triggered by photoperiod, increased temperature or increased flow	Benthic habitats in main channel, not recorded from floodplain habitats. Proportion of larvae drift downstream during night.	Perennial flow. Eggs laid in pools > 50 cm deep. Preferred pool depth >1 m. Spawning migration not necessarily triggered by flow but increased flows may facilitate spawning movement in later winter spring.
Trout Cod	Deep water, fast flowing streams with snags or boulders. Preference is towards woodpiles rather than single logs.	No evidence of migration associated with spawning	Observed in adults habitat, also amongst small debris and on sandy beaches. Proportion of larvae drift downstream at night.	Perennial flow. Preferred pool depth >1 m.
Golden perch	Deep water, slow flowing streams with snags.	May undertake an upstream spawning migration, but spawning still occurs in non-flood years	Benthic habitats in main channel, not recorded from floodplain habitats. Eggs and larvae drift downstream.	Perennial flow. Preferred pool depth >1 m. Spawning migration not necessarily triggered by flow but increased flows may facilitate spawning movement in later winter spring and floods may improve recruitment success.
Macquarie Perch	A riverine species typically found in deep pools of slow flowing rivers.	Migration not necessary in riverine populations	Larvae swept downstream from riffles but rapidly seek cover on stream bed	Perennial flow. Eggs laid in riffles up to 1 m deep. Increased flow prior to spawning (spring to early summer) may improve egg incubation success by flushing sediment.
Australian Smelt	River & floodplain environments with preference for slow flowing river-edge & backwater habitats with submerged vegetation.	Frequently move through fishways, but movement is not associated with spawning	Larvae may make upstream dispersal movement in spring & summer during increased flows.	Perennial flow. Larvae & juvenile may undertake upstream movement in spring & summer in response to small increases in flow.

6.3 Reach condition summary

The main fish related issues and condition of the current fish community as described in detail above are summarised in Table 6-5. Key threats to reaches in the study area are from low flows in summer as a result of excessive extraction, lack of suitable instream habitat as result of extensive historical snag removal and the poor condition of the riparian zone, particularly given that the riparian zone in most reaches is dominated by introduced species (willows and blackberries) that do not provide a suitable source of future supply of large woody debris. Barriers to fish passage also represent a risk by restricting fish movement, particularly the recolonisation of the upper Ovens River by large native fish currently present in the lower reaches (ie. golden perch and trout cod). Predation by trout on small native species (eg. mountain galaxias and southern pygmy perch) poses a risk to these species.

Table 6-5 Summary of habitat flow and other issues affecting fish in the Ovens River study area

Reach	Fish issues
Reach 1: Ovens River upstream of the Morses Creek confluence	**General condition** ▪ Excellent to good ▪ Good abundance of small native fish, particularly two-spined blackfish **Habitat:** ▪ Excellent to good **Flows:** ▪ Not flow affected **Threats:** ▪ Predation of small native fish by trout
Reach 2: Ovens River from the Morses Creek confluence to the Buckland River confluence	**General condition** ▪ Excellent to good ▪ Good abundance of small native fish, particularly two-spined blackfish and mountain galaxias ▪ **Habitat:** ▪ Excellent to good **Flows:** ▪ Not flow affected **Threats:** ▪ Predation of small native fish by trout ▪ Barriers to fish passage at Bright and Porpunkah

Reach	Fish issues
Reach 3: Ovens River from the Buckland River confluence to the Buffalo River confluence	**General condition** ▪ Good to moderate ▪ Good abundance of small native fish, particularly two-spined blackfish, river blackfish and mountain galaxias ▪ Predicted large bodied fish (Murray cod, trout cod, golden perch and Macquarie perch) are mostly absent from reach **Habitat:** ▪ Good to moderate ▪ Low abundance of snags **Flows:** ▪ Maybe some impact from lower summer flows if it results in a reduction in pool depth **Threats:** ▪ Barriers to fish passage at Tea Garden Creek ▪ Lack of instream snag habitat ▪ Exotic fish
Reach 4: Morses Creek	**General condition** ▪ Excellent to good ▪ Good abundance of small native fish, particularly two-spined blackfish **Habitat:** ▪ Excellent to good **Flows:** ▪ Extractions may exacerbate stress on community during summer low flow period **Threats:** ▪ Predation of small native fish by trout
Reach 5: Buckland River	**General condition** ▪ Excellent to good ▪ Good abundance of small native fish, particularly two-spined blackfish, river blackfish and mountain galaxias ▪ Native fish population is recovering from 2003 fires (98% reduction in native fish abundance following 2003 bushfires and sediment slug **Habitat:** ▪ Excellent to good **Flows:** ▪ Maybe some impact from lower summer flows if it results in a reduction in pool depth **Threats:** ▪ Predation of small native fish by trout

Reach	Fish issues
Reach 6: Buffalo Creek	**General condition** ▪ Excellent in upper reaches ▪ Poor to moderate in lower reaches with low abundance of small native fish **Habitat:** ▪ Good in upper reaches ▪ Poor in lower reaches due to lack of instream habitat **Flows:** ▪ Extractions may exacerbate stress on community during summer and autumn low flow period **Threats:** ▪ Lack of instream habitat ▪ Predation of small native fish by trout
Reach 7: Happy Valley Creek	**General condition** ▪ Moderate to poor ▪ Low abundance of small native fish **Habitat:** ▪ Poor instream habitat with no snags and no riparian zone ▪ Evidence of siltation **Flows:** ▪ Extractions may exacerbate stress on community during summer and autumn low flow period **Threats:** ▪ Stock access ▪ Willows ▪ Nutrient inputs ▪ Catchment erosion ▪ Exotic fish
Reach 8: Barwidgee Creek	**General condition** ▪ Moderate to poor ▪ Low abundance of small native fish **Habitat:** ▪ Poor instream habitat with no snags and very narrow riparian zone. ▪ Evidence of siltation **Flows:** ▪ Extractions may exacerbate stress on community during summer and autumn low flow period **Threats:** ▪ Stock access ▪ Willows ▪ Nutrient inputs ▪ Catchment erosion ▪ Exotic fish

6.4 General fish management recommendations

The general recommendations for managing fish communities in the Ovens River and tributaries are:

Flow related

a. To provide low flows during summer and autumn of sufficient volume to maintain suitable pool depth for both small and large bodied native species.

b. To protect high flows and floods that facilitate upstream and downstream movement of native fish and enhance recruitment success, particularly Murray cod, trout cod and golden perch, during winter and spring.

c. To provide fresh and high flows that flush sediment from benthic surfaces and scour benthic biofilms to maintain habitat quality and spawning sites for river and two-spined blackfish, Murray cod, trout cod and Macquarie perch.

Non-flow related

a. To restore snag habitat and restore the riparian zone so that there is a succession of potential snag habitat into the future. This is particularly important if Murray cod, trout cod and possibly golden perch are to move into Reaches Two and Three of the Ovens River.

b. To allow unimpeded movement of fishes throughout the Ovens River system, particularly opportunities for movement between the lower Ovens River and the study area. The Lower Ovens River supports significant populations of Murray cod, trout cod and golden perch that may act as a source of recruitment and recolonisation to Reach 3 in the study area.

c. To work towards sustainable populations of native fish in the Ovens River system, which may initially require stocking of some species (eg. trout cod, golden perch and Macquarie perch), but with the idea that natural recruitment processes will eventually take over.

d. To reduce the impacts of exotic species through the provision of suitable habitat and flows that enhance conditions for native fish and through the cessation of trout releases.

7. Water quality

7.1 Background and condition

7.1.1 Available data and information

Water quality is routinely monitored at only three established Victorian Water Quality Monitoring Network (VWQMN) sites in the upper Ovens River (Table 7-1). Monthly in-situ monitoring for pH, temperature, dissolved oxygen, electrical conductivity and turbidity commenced in the Ovens River at Bright and Myrtleford in 1975 and at Harrietville in 1986 (Table 7-1). Nutrient monitoring is also conducted at these sites, but the record is not as long (Table 7-1). Metals are only routinely monitored at Harrietville and Bright (Table 7-1). In-situ water quality monitoring also commenced in Morses Creek, Buckland River, Buffalo Creek, Happy Valley Creek and Barwidgee Creek in 1975, but there has been no routine monitoring in these reaches for at least 18 years (Table 7-1).

- **Table 7-1: Established water quality monitoring sites in the upper Ovens River system.**

VWQMN Site #	Location	FLOWS reach	In-situ monitoring record	Nutrient monitoring record	Metals monitoring record
403244	Ovens River at Harrietville	1	1986 - current	1987 - current	1987 - current
403205	Ovens River at Bright	2	1975 - current	1977 - current	1985 - current
403210	Ovens River at Myrtleford	3	1975 - current	1990 - current	
403232	Morses Creek at Wandiligong	4	1975 - 1988		
403233	Buckland River at Harris Lane	5	1975 - 1988		
403216	Buffalo Creek at Myrtleford	6	1975 - 1982		
403214	Happy Valley Creek at Rosewhite	7	1975 - 1988		
403236	Barwidgee Creek at Myrtleford	8	1975 - 1976		

Data from established VWQMN sites have been used in many studies including the 1999 and 2004 ISC assessments. The Victorian EPA also measured water quality in conjunction with macroinvertebrate sampling at 20 sites throughout the upper Ovens River (Miller and Barbee 2003). The EPA data provides a snap-shot of conditions at the time that biological samples were taken, but lacks the temporal replication required to broadly characterise conditions at a particular site. Intensive water quality monitoring was also undertaken by several agencies to track the impact of a flash flood following the 2003 bushfires that flushed a large sediment slug into the Buckland and Ovens Rivers (DSE 2003b). The following section draws on information contained in these and other summary reports for the Ovens River catchment.

7.1.2 Temporal trends in water quality at routine monitoring sites

pH levels at the three VWQMN sites in the upper Ovens River fluctuated between sampling occasions, but there were no clear seasonal patterns (Figure 7-1). Monthly pH readings at all sites between 2000 and 2004 were generally within the SEPP (WoV) 25th and 75th percentile objectives (6.4 – 7.7) for the Forests B region, which covers most of the upper Ovens River study area (Figure 7-1). However, a very low reading (4.9 – indicating high acidity) was recorded at Myrtleford in April 2002. It is not clear what caused this low reading, but subsequent measures at that site were within or close to the SEPP (WoV) objectives. pH readings at all sites were less than, or only slightly greater than, the SEPP (WoV) 25th percentile objective between December 2004 and May 2005, but then returned to normal levels for the latter half of 2005 (Figure 7-1). This drop in pH may be due to an increased breakdown of organic matter in the sediments during pronounced summer low flows and may be an effect of the current drought and flow stress on the system.

Dissolved oxygen levels at all three VWQMN sites in the upper Ovens River show a strong seasonal pattern (Figure 7-1). Cooler water temperatures and higher flows contribute to dissolved oxygen levels around 11-12 mg/L at all sites during winter. However, dissolved oxygen levels fall below 8 mg/L at most sites during summer (Figure 7-1). Dissolved oxygen concentration is inversely related to water temperature, which may explain why summer dissolved oxygen levels at Myrtleford were consistently lower than at Bright and Harrietville. These seasonal fluctuations are normal and dissolved oxygen levels on all sampling occasions were well above any level that may be considered a threat to aquatic life. The SEPP (WoV) 25th percentile objective for dissolved oxygen in the Forests B region is between 7.5 and 9.5 mg/L at 25°C; the 25th percentile value for each of the VWQMN sites in the upper Ovens River will be above this limit and therefore dissolved oxygen levels in this catchment are considered to be at acceptable levels.

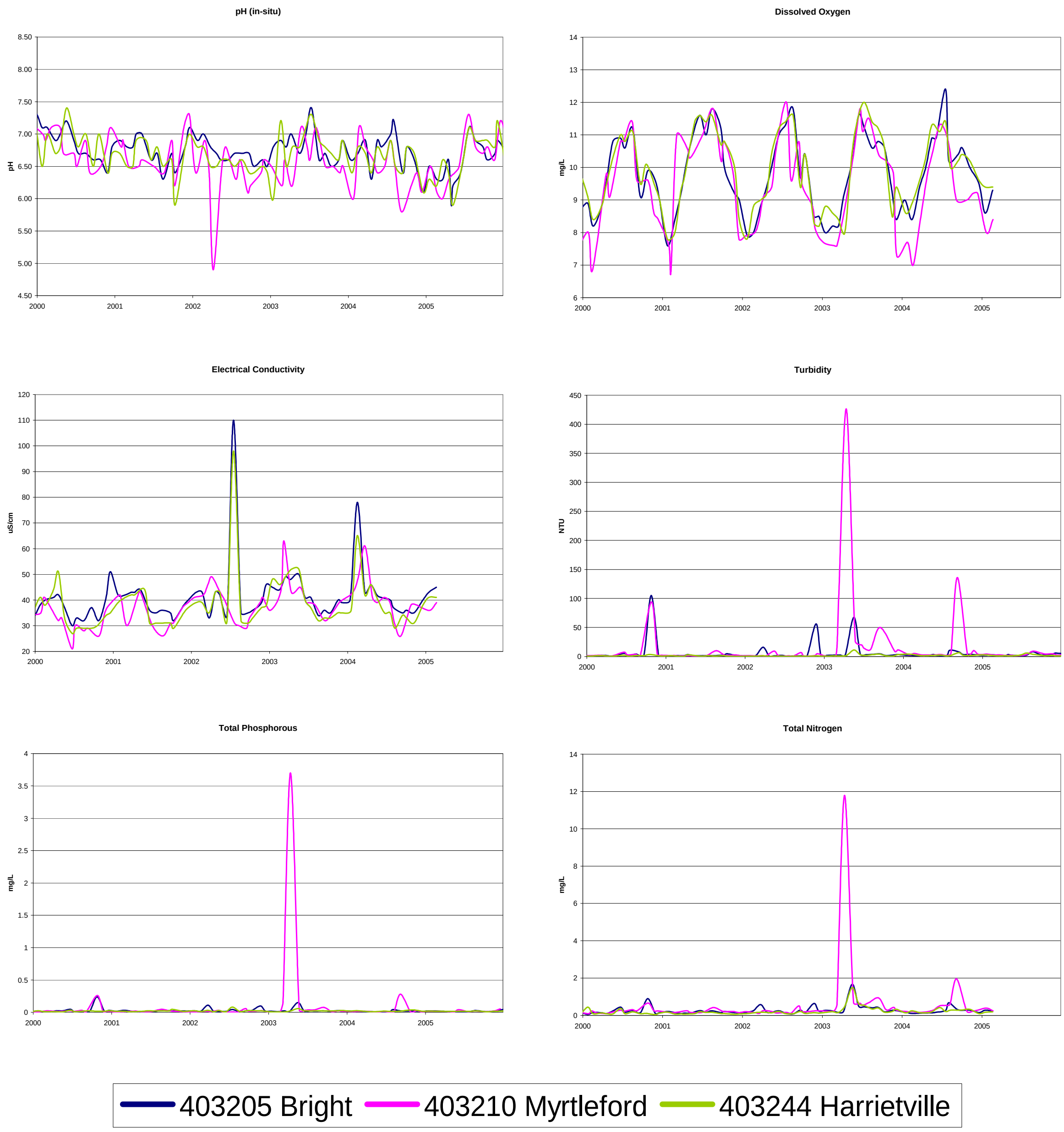
Electrical conductivity at all monitoring sites ranged between 20 and 80 µS/cm between 2000 and 2005 and readings were generally higher in summer than winter, but a large spike was recorded at Harrietville and Bright in July 2002 (Figure 7-1). The cause for this peak in electrical conductivity is not clear, but only one record at one site exceeded the SEPP (WoV) 75th percentile objective (100 µS/cm) for electrical conductivity in the Forests B region. It is worth noting that electrical conductivity levels at all sites were slightly higher in summer 2004 and summer 2005 than in the previous three years, which may be due to lower than normal flows and reduced flushing effects in these years. Overall, the relatively low electrical conductivity levels recorded at these sites confirms other reports that salinity is not a significant issue in the upper Ovens River (North East

CMA 2000), but salinity levels should be carefully monitored during the current drought to ensure that levels do not rise to threatening levels.

The Ovens River upstream of Myrtleford normally has very clear water. Turbidity levels at the three Ovens River monitoring sites have been below 10 NTU (and often below 4 NTU) on most sampling occasions over the last five years (Figure 7-1), which is well below the SEPP (WoV) objective for the Forests B region. However, higher turbidity levels were recorded during high flow events at Bright and Myrtleford (Figure 7-1). The highest turbidity reading in this data series (426 NTU) was recorded at Myrtleford on 15 April 2003, but normal turbidity readings were recorded at Bright and Harrietville on this day (Figure 7-1). This high reading at Myrtleford was associated with a flash flood in the Buckland River on 26 February 2003 that flushed a sediment slug from bushfire affected areas into the Buckland and Ovens Rivers. The sediment slug moved through the Buckland and Ovens Rivers relatively quickly, but caused a peak turbidity reading of 70,000 NTU at Myrtleford on 27 February 2003 (DSE 2003b). Routine water quality monitoring was not conducted at the Myrtleford VWQMN site in March 2003, but the April 15 result indicates that a large level of suspended sediment persisted in the system for some time. Turbidity readings at Myrtleford in September 2003 and September 2004 were much higher than any other records between January 2001 and February 2003 and are probably due to the remobilisation of fine sediments that were deposited in the initial slug. It is likely that future high flow events will also mobilise remnant material and lead to unnaturally high turbidity peaks.

Between 1978 and 1985 total phosphorus levels at Bright regularly exceeded 25 µg/L (Figure 7-2), which is the current SEPP (WoV) objective for the annual 75th percentile in the Forests B region. Septic tanks were probably the source of this high nutrient load, particularly in wet years when saturated soils allow nutrient leaching from tanks to groundwater and surface water. The development of a wastewater treatment plant at Bright in the mid 1980's and connection of properties to this sewer system coincided with reduced total phosphorus concentrations in the upper Ovens River and monthly monitoring indicates that the current SEPP (WoV) objective would have been met in approximately two out of three years at all three VWQMN sites since 1994 (Figure 7-2). Peaks in total phosphorus concentrations occurred 1-2 times per year at each of the upper Ovens River monitoring sites between 2000 and 2005, but the magnitude of these peaks varied between sites (Figure 7-1). The maximum peak recorded at Harrietville during this period was 80 µg/L and the maximum peak at Bright was 250 µg/L. The spike in total phosphorus concentration (3700 µg/L) recorded at Myrtleford in April 2003 (Figure 7-1) is due to the sediment slug that was washed down the Buckland River after the 2003 bushfires (DSE 2003b). Total phosphorus concentrations during and immediately after the slug passed through Myrtleford would most likely have been at least an order of magnitude higher than the concentration recorded in routine monitoring, but this result shows that high nutrient concentrations persisted for several months after the initial impact. Subsequent spate events at Myrtleford have not been associated with abnormally high total phosphorus levels, which suggest that there is little residual effect of the sediment slug.

Between 1978 and 1985 total nitrogen levels at Bright regularly exceeded 350 µg/L (Figure 7-2), which is the current SEPP (WoV) objective for the annual 75th percentile in the Forests B region. Subsequent upgrades to wastewater treatment at Bright coincide with reduced total nitrogen concentrations in the upper Ovens River and monthly monitoring indicates that the current SEPP (WoV) objective for nitrogen would have been met every year at each VWQMN site between 1989 and 2002 (Figure 7-2). The high total nitrogen concentrations recorded in 2003 are probably due to sediment inflows from fire affected areas and were most pronounced in the Ovens River at Myrtleford, which received very large sediment inputs from the February 2003 flood in the Buckland River (DSE 2003b). Small peaks in total nitrogen concentrations were associated with higher spring flows at most sites between 2000 and 2002, but all readings throughout 2003 were higher than normally occurs at these sites (Figure 7-1). As with the plot of annual 75th percentile statistics, the monthly monitoring data highlights the post fire increase in total nitrogen concentrations at all sites, but especially at Myrtleford (Figure 7-1).



- **Figure 7-1: Plots showing temporal patterns in pH, dissolved oxygen, electrical conductivity, turbidity, total phosphorus and total nitrogen at the three VWQMN sites in the upper Ovens River. Available data from January 2000 to December 2005 are shown (data for some measures were not available for 2005). Data sourced from (DSE 2006c).**

- **Figure 7-2: Plots showing the annual 75th percentile measures for total phosphorus and total nitrogen at the three VWQMN sites in the upper Ovens River. Available data record for each site has been used. Data sourced from (DSE 2006c).**

7.1.2.1 Summary of temporal water quality patterns

Aside from the effects of the 2003 bushfires, overall water quality at the three VWQMN sites in the upper Ovens River is good and is within the SEPP (WoV) objectives for the Forests B region of Victoria. However, recent results indicate a slight increase in salinity and a decrease in pH over the last two summers. These patterns may be due to flow stresses in the river associated with the current drought and it is possible that continued or further flow stresses during summer may have a detrimental effect on some water quality measures.

7.1.3 2004 ISC assessment

The ISC water quality sub-index is based on five years of monthly data for total phosphorus, turbidity, electrical conductivity and pH. Ratings for each indicator are determined by comparing the 75th percentile statistic for all indicators and the 25th percentile statistic for pH against defined 'reference' water quality conditions for that region (Table 7-2). A total sub-index score (out of 10) for each reach is calculated by proportionally summing the rating scores for each indicator.

- **Table 7-2: Five point rating system for the 2004 ISC water quality sub-index (DSE 2006b).**

Category	Rating
High quality reference state	4
Acceptable reference state	3
Moderate modification from reference state	2
Major modification from reference state	1
Extreme modification from reference state	0

The 2004 ISC referred to water quality data collected in two reaches of the upper Ovens River:

- Reach 5 – Ovens River from Buckland River confluence to Buffalo River confluence
- Reach 6 – Ovens River from Harrietville to Buckland River confluence.

The results of this assessment indicate that water quality upstream of the Buckland River is very good to excellent, but is degraded downstream of the Buckland River (Table 7-3). The difference between the two ISC reaches is due to differences in two indicators. Total phosphorus and turbidity levels in the Ovens River between the Buckland River and Buffalo River were much higher than the expected reference condition for this part of the state. High phosphorus and turbidity levels in this reach are probably due to the impact of the sediment slug that was washed into the Buckland River after the 2003 bushfires (DSE 2003b). As the information presented in section 7.1.2 demonstrates, the impact of this sediment slug is diminishing over time and the poor overall rating for ISC Reach 5 is probably a temporary state. Electrical conductivity and pH levels in both reaches were equivalent to the reference condition for this reach and indicate that salinity is not an issue for this part of the catchment

- **Table 7-3: 2004 ISC water quality results for the upper Ovens River (DSE 2005).**

	Reach 5 – Buckland River to Buffalo River			Reach 6 – Harrietville to Buckland River		
Indicator	25th percentile	75th percentile	Rating	25th percentile	75th percentile	Rating
Total phosphorus		47	1		23	3
Turbidity		38.25	0		3.95	4
Electrical conductivity		43.25	4		44.75	4
pH	6.475	6.65	3	6.7	7	4
Overall Score	5 out of 10 – Moderate condition			9 out of 10 – Excellent condition		

7.2 Spatial comparison of water quality throughout the upper Ovens River.

Snap shot water quality samples taken in conjunction with the EPA biological monitoring program (Miller and Barbee 2003) provide a spatial comparison of water quality conditions throughout the upper Ovens Catchment. The results presented in Table 7-4 are the average of two sampling events (autumn and spring) at each site, but sites were not all sampled in the same years and the results should not be considered an accurate measure of typical conditions at each site.

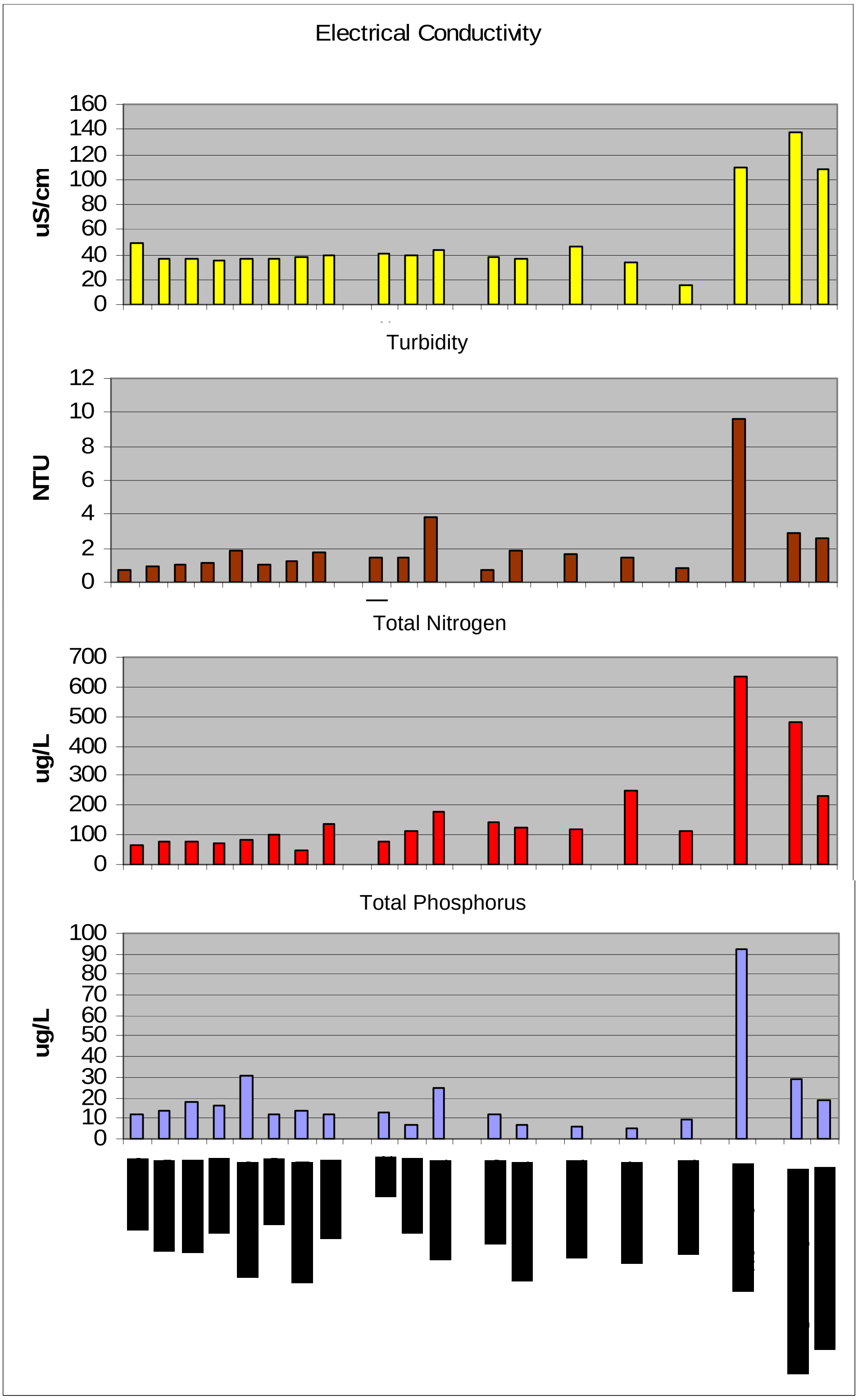
- **Table 7-4: Water quality data from EPA biological monitoring sites in the upper Ovens River. Data are the average of two sampling events (autumn and spring) taken between 1998 and 2000. Source (Miller and Barbee 2003)**

Site	TP (µg/L)	TN (µg/L)	Turbidity (NTU)	EC (µS/cm)
Reach 1:				
Ovens River at Harrietville	12	66	0.7	49
Ovens River upstream of Fish Farm	14	80	0.9	37
Ovens River downstream of Fish Farm	18	77	1	37
Ovens River downstream of Smoko	16	70	1.1	35
Ovens River at McMahons Lane	31	83	1.9	36
Ovens River at Mills View	12	100	1	37
Ovens River at Old Harrietville Rd	14	46	1.2	38
German Ck north of Germantown *	12	134	1.8	39
Reach 2:				
Ovens River at Bright	13	79	1.4	41
Ovens River at Braithwaite Pumping station	7	114	1.4	39
Roberts Creek at Roberts Creek Road *	25	176	3.8	44

Site	TP (µg/L)	TN (µg/L)	Turbidity (NTU)	EC (µS/cm)
Reach 3:				
Ovens River upstream Myrtleford (Selzers Lane)	12	144	0.7	38
Ovens River downstream Buffalo Creek	7	122	1.9	36
Reach 4:				
Morses Creek at Hawthorne Creek	6	117	1.7	46
Reach 5:				
Buckland River at Mt Buffalo Rd	5	247	1.5	34
Reach 6:				
Buffalo Creek at Buffalo Ck Rd	9	115	0.8	16
Reach 7:				
Happy Valley Creek at Mudgeegonga Rd	92	634	9.6	110
Reach 8:				
Barwidgee Creek at Myrtleford Rd	29	481	2.9	138
Barwidgee Creek at Myrtleford	19	232	2.6	108

The EPA snap-shot water quality data shows that overall water quality conditions in the Ovens River upstream of Myrtleford are generally very good or excellent, but some tributaries throughout the upper Ovens River have high turbidity levels and high nutrient concentrations (Figure 7-3). Differences between sites in Reaches 1 and 2 probably reflect point source impacts from small tributaries and individual properties, or else reflect localised diffuse impacts such as run-off from a particular crop or more urbanised area. Happy Valley Creek and Barwidgee Creek have the poorest water quality, which probably reflects the high level of erosion and other disturbances in these catchments. Roberts Creek, which is a small urbanised tributary near Bright also has relatively poor water quality. The lower reaches of Buffalo Creek has extensive agriculture and may have relatively poor water quality, but the monitoring site for this catchment was upstream of the main impacted area. Buffalo Creek, Happy Valley Creek and Barwidgee Creek had higher salinity levels compared to other parts of the upper Ovens River catchment (Figure 7-3) and were slightly higher than the SEPP (WoV) 75^{th} percentile objective of 100 µS, but given that these results are based on only two sampling occasions it is not possible to say whether the SEPP (WoV) objective would be triggered at these sites.

Poor water quality in the tributaries of the upper Ovens River is primarily a consequence of urban and agricultural land use practices. In particular, catchments such as Happy Valley Creek and Barwidgee Creek have high levels of erosion, which probably contribute to the very high nutrient loads. Nutrients exported from these tributaries affect water quality in the Ovens River downstream of Myrtleford and increase the risk of algal blooms in the lower reaches of the Ovens River and in Lake Mulwala (North East CMA 2000).



- **Figure 7-3: Plot showing snap-shot water quality conditions at EPA monitoring sites throughout the upper Ovens River. Data taken from (Miller and Barbee 2003).**

7.3 Water quality impact sources

Various diffuse and point source impacts are likely to affect water quality throughout the upper Ovens River catchment. Nutrients can enter waterways through run-off and leaching from fertilized or livestock pastures, urban stormwater, leaching from septic tanks, discharge from wastewater treatment plants and general catchment erosion (Breen 2000, Hunter 2000).

Erosion, fertilizer use and livestock are likely to be the main factors contributing to poor water quality in Happy Valley Creek and Barwidgee Creek. Nutrients readily attach to fine soil particles and are transported to receiving waters via catchment erosion (Hunter 2000). Land clearing and unrestricted stock access to rivers and streams substantially increases erosion throughout parts of the upper Ovens River catchment and delivers high sediment and nutrient loads to some streams. Stock fencing and riparian planting are likely to control erosion along these watercourses and reduce nutrient inputs to the streams and should be considered a management priority.

Saturated soils, such as occur during particularly wet periods, can facilitate nutrient leaching from septic tanks to groundwater. Groundwater contributes a substantial proportion of flow to all waterways in the upper Ovens River catchment and therefore this leaching can affect water quality in surface waters. The major urban centres such as Bright, Myrtleford and Harrietville were connected to the mains sewer during the 1980's and noticeable drops in total phosphorus and total nitrogen levels were observed in the Ovens River after this time. Some homes throughout the catchment still have septic tank systems and therefore may contribute to nutrient loads in streams at certain times, but these properties are generally in isolated areas with low density development and therefore their total impact on the system is likely to be small.

The Bright/Porepunkah Wastewater Treatment Plant is the main treatment facility in the Upper Ovens catchment and is likely to be a major point source polluter. Treated waste from this facility is discharged to groundwater via a gravel pit that is approximately 400m from the Ovens River. Some filtering is likely to occur through the gravel pit and soils, but groundwater entering the Ovens River from this location is likely to carry relatively high nutrient loads. There is no routine nutrient monitoring immediately downstream of the treatment plant and therefore the specific impact of this discharge on water quality has not been quantified. NERWA are currently upgrading the Bright/Porepunkah WWTP so that it can treat to a tertiary standard. It is expected that tertiary treated water will be re-used for watering throughout the catchment and will therefore eliminate the need to discharge to groundwater or surface water.

7.4 Effects of modified flow

Water extractions do not appear to have had a major influence on water quality conditions in the main stem of the Ovens River upstream of the Buffalo River. Poor water quality conditions can sometimes occur immediately downstream of urban centres or point source agricultural inputs, but there is generally enough flow in the Ovens River to dilute such impacts and most sections of the upper Ovens River have very good to excellent water quality.

The main area where the modified flow regime is likely to affect water quality is in the tributaries. Some tributaries of the upper Ovens River have poor water quality, which is likely to be exacerbated during summer low flow periods. These small catchments tend to have small total discharge levels and variable flow regimes, and water extraction in these catchments can further reduce flow during low flow periods and therefore increase nutrient or salt concentrations in the waterways.

7.5 Reach condition summary

The main water quality issues in the upper Ovens River are summarised for each of the study reaches in

- **Table 7-5: Summary of water quality issues identified in each of the environmental flows study reaches.**

Reach	Water quality issues
Reach 1: Ovens River upstream of Morses Creek	**General condition:** ▪ Excellent **Nutrient enrichment:** ▪ Locally elevated near urban centres **salinity:** ▪ Very low **Flows:** ▪ Reduced summer flows may temporarily increase salinity, nutrients and reduce pH. **Threats:** ▪ Point source and localised impacts may contribute to higher nutrient levels in some places
Reach 2: Ovens River between Morses Creek and the Buckland River	**General condition:** ▪ Excellent **Nutrient enrichment:** ▪ Locally elevated near urban centres including tributaries such as Roberts Creek **salinity:** ▪ Very low **Flows:** ▪ Reduced summer flows may temporarily increase salinity, nutrients and reduce pH. **Threats:** ▪ Point source and localised impacts may contribute to higher nutrient levels in some places

Reach	Water quality issues
Reach 3: Ovens River between the Buckland River and Buffalo River	**General condition:** ▪ Very good, but was badly affected by the 2003 bushfires **Nutrient enrichment:** ▪ Locally elevated near urban centres and high after 2003 fires **salinity:** ▪ Very low **Flows:** ▪ Reduced summer flows may temporarily increase salinity, nutrients and reduce pH. **Threats:** ▪ Point source and localised impacts (e.g. discharge from WWTP) may contribute to higher nutrient levels in some places
Reach 4: Morses Creek	**General condition:** ▪ Very good to excellent ▪ Conditions deteriorate near Bright and Wandiligong **Nutrient enrichment:** ▪ Locally elevated near urban centres **salinity:** ▪ Very low **Flows:** ▪ Reduced summer flows may temporarily increase salinity, nutrients and reduce pH. **Threats:** ▪ Point source and localised impacts may contribute to higher nutrient levels in some places
Reach 5: Buckland River	**General condition:** ▪ Excellent in upper sections, but deteriorates further downstream as passes through agricultural areas ▪ Turbidity and nutrients extremely high after 2003 bushfires **Nutrient enrichment:** ▪ Effects of fire ▪ Agricultural inputs in lower sections – also evidence of some filamentous algae near confluence with Ovens **salinity:** ▪ Very low **Flows:** ▪ Unknown, but reduced summer flows may temporarily increase, nutrients and reduce pH.

Reach	Water quality issues
	Threats: ▪ Point source and localised impacts may contribute to higher nutrient levels in some places
Reach 6: Buffalo Creek	**General condition:** ▪ Very good to good **Nutrient enrichment:** ▪ Agricultural run-off and stock access are main nutrient inputs to this reach. **salinity:** ▪ Very low **Flows:** ▪ Reduced summer flows may temporarily increase, nutrients and reduce pH. **Threats:** ▪ Point source and localised impacts may contribute to higher nutrient levels in some places
Reach 7: Happy Valley Creek	**General condition:** ▪ Poor **Nutrient enrichment:** ▪ Catchment erosion, stock access to stream channel and cropping to stream edge contribute high nutrient levels to the creek **salinity:** ▪ High compared to other parts of the catchment **Flows:** ▪ Reduced summer flows may exacerbate water quality problems in this catchment – specifically increase nutrients and salinity. **Threats:** ▪ Point source and localised impacts from individual properties, diffuse run-off and catchment erosion may increase nutrient levels in some places, which may contribute to algal growth and increase nutrient inputs to downstream waterways.
Reach 8: Barwidgee Creek	**General condition:** ▪ Poor **Nutrient enrichment:** ▪ Catchment erosion, stock access to stream channel and cropping to stream edge contribute high nutrient levels to the creek **salinity:** ▪ High compared to other parts of the catchment **Flows:**

Reach	Water quality issues
	▪ Reduced summer flows may exacerbate water quality problems in this catchment – specifically increase nutrients and salinity. **Threats:** ▪ Point source and localised impacts from individual properties, diffuse run-off and catchment erosion may increase nutrient levels in some places, which may contribute to algal growth and increase nutrient inputs to downstream waterways.

7.6 General water quality management recommendations

Flow related and other general recommendations for managing water quality in the upper Ovens River include:

1) Flow related recommendations
   a) Ensure adequate flows to minimise nutrient concentrations and salinity in tributaries during summer.
2) Non-flow related recommendations:
   a) Control erosion, particularly in Happy Valley Creek and Barwidgee Creek catchments;
   b) Control stock access to the stream in all reaches;
   c) Provide buffers to reduce agricultural run-off throughout the catchment;
   d) Improve wastewater treatment operations and wastewater disposal in urban areas (this is likely to be addressed through planned upgrades to the Bright/Porepunkah WWTP); and
   e) Increase sewer connections in areas still using septic tanks.

8. Macroinvertebrates

8.1 Background and condition

8.1.1 Available data and information

The Victorian EPA surveyed macroinvertebrate communities in the upper Ovens River as part of the National River Health Program (1998-2002) and the two Victorian Index of Stream Condition (ISC) assessments in (1999 and 2004). The EPA also has a number of long term biological monitoring sites in the area and sampled macroinvertebrate communities in the Ovens River at Myrtleford (as well as two sites further downstream) in 2003 to assess the impact of a post bushfire flood (DSE 2003b). The Ovens Basin was also used for the macroinvertebrate component of the Sustainable Rivers Audit Pilot study (MDBC 2004b), but only one of these sites was in the upper Ovens River.

Macroinvertebrate communities have been assessed at approximately 20 sites in the upper Ovens River between 1997 and 2004 under the National River Health Program, ISC and EPA long term monitoring programs. Data from these studies have been summarised in numerous reports that describe the condition of the Ovens River (e.g. EPA 2003, Miller and Barbee 2003, DSE 2005). The information presented in this *Issues Paper* predominantly relies on the summarised data presented in these reports, but also discusses the findings of the post fire sampling event.

8.1.2 Measures used to assess macroinvertebrate community condition

Five key indices are commonly used to describe macroinvertebrate community composition for the purposes of assessing environmental condition. These indices are used in most published studies and are described below to provide a context for the macroinvertebrate component of this *Issues Paper*.

The Australian Rivers Assessment System (AUSRIVAS) compares observed macroinvertebrate communities against a reference condition that would be predicted to occur at a particular site if there was little or no degradation. AUSRIVAS scores are given a band rating that indicates whether they are equivalent to reference, below reference, well below reference, impoverished or richer than reference. All ratings other than equivalent to reference are considered to indicate degradation. Communities that are richer than reference usually occur at sites with organic enrichment. A Key Family Index is sometimes used if a reliable reference condition cannot be determined for a particular region. The Key Family Index focuses on those families that are indicative of good condition and are typically found in streams for that particular region. The absence of Key Families from a particular site is likely to be an indication of degradation.

Stream Invertebrate Grade Number Average Level (SIGNAL) scores provide a measure of pollution sensitivity. Individual macroinvertebrate families are scored between 1 (very tolerant) and 10 (very sensitive) depending on their known sensitivity. Scores for all macroinvertebrate families collected at a site are averaged to produce an overall score for the community. A high SIGNAL score indicates good ecological condition; a low SIGNAL score indicates site degradation.

The Number of Families collected at a particular site using rapid biological assessment techniques can be used as a coarse measure of condition. In general, sites in good condition will have more families than degraded sites. However, some organically enriched sites may support a high abundance and diversity of macroinvertebrates. The number of families collected at a particular site can also vary over time.

The EPT index is a measure of the number of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) families that occur at a particular site. These insect orders are generally sensitive to pollution and disturbance and therefore communities with high numbers of families in these orders generally indicate a healthy stream.

The SEPP Waters of Victoria (WoV) provides objectives for each of these biological measures in each of the bioregions throughout Victoria. Sites that fail to meet the objectives for two or more biological measures are considered likely to be degraded and trigger further investigation.

8.1.3 Habitat and general community overview

The upper Ovens River and its tributaries are located within the Victorian biological objective region of Forest B (EPA 2004). This region includes foothill areas of the Great Dividing Range, including sections of the Alpine National Park. Streams in this region have moderate slope and the catchments receive moderate to high local rainfall (Miller and Barbee 2003). Most streams throughout the upper Ovens River catchment are characterised by the presence of riffles and edges with very coarse substrate, moderate macrophyte diversity and dense cover (EPA 2004). Some bedrock features are also present and some sites have shallow runs rather than deep pools. Diverse physical habitats and a mix of high and low flow environments throughout the upper Ovens River catchment helps support a very diverse macroinvertebrate community with many mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) (Cottingham *et al.* 2001) that are typical of upland cobble streams. Beetle larvae (Coleoptera), water bugs (Hemiptera) and dragonflies (Odonata) are more common at the downstream end of the study region (Cottingham *et al.* 2001) and are also likely to be more abundant in tributaries that are impacted by high sediment loads.

Flow variability is important for macroinvertebrate communities in cobble streams. Periodic high flows turn over individual substrate elements, which redistributes organic material through the hyporheus and prevents interstitial infilling and substrate packing (Matthaei *et al.* 1999). If the substrate becomes too tightly packed, then there will be limited flow and oxygen exchange between the substrate layers and the main water column. Many macroinvertebrates directly use the underneath of cobbles and spaces between substrate elements for habitat throughout their whole lifecycle or for particular life history stages and therefore the amount of available habitat as well as the amount of organic matter and oxygen in these habitats has a large influence on macroinvertebrate communities in these streams. Summer freshes mobilise particulate organic matter, which is an important food source for many filter feeding species (Alstad 1986) and also overturn some small cobbles, which can deliver new biofilms and food to species that scrape food from the underside of stones. Summer low flows expose the tops of larger cobbles and boulders in the middle of the channel. These exposed rocks provide important oviposition cues for adult insects (Lancaster *et al.* 2003, Reich and Downes 2003a, b) and also create local patches of still water that provide deposition zones for organic matter and dispersing macroinvertebrates and increase overall habitat diversity (Bond *et al.* 2000, Weins 2002).

Land clearing and the proliferation of exotic plant species can also have a detrimental effect on macroinvertebrate habitats and therefore macroinvertebrate community composition. Extensive land clearing and unrestricted stock access to waterways has increased erosion in some parts of the Upper Ovens River catchment and contributed high sediment loads to some waterways. The macroinvertebrate fauna of the upper Ovens River would have naturally been dominated by upland species that inhabit cobble substrates and are adapted to moderate flow conditions. Fine sediments can smother important macroinvertebrate habitats on the surface of cobbles and in the spaces between cobbles (Wood 1997). Fine suspended sediments can also clog macroinvertebrate breathing structures and interfere with the feeding habits of many filter feeding species (Wood 1997). The dominance of willows and other exotic plant species along the riparian zone of many streams in the upper Ovens River catchment are likely to affect macroinvertebrate communities in three ways. First, winter deciduous species such as willows deliver a large amount of leaf litter into streams in autumn. Leaf litter is an important food source for many macroinvertebrates, but communities in the upper Ovens River would have normally responded to a more even supply throughout the year (Schulze and Walker 1997, Read and Barmuta 1999). Second, willow roots form a dense mat that can smother the stream bed and reduce instream habitat for macroinvertebrates (Schulze and Walker 1997, Read and Barmuta 1999). Finally, dense shading by willows can affect water temperatures and therefore macroinvertebrate growth rates (Schulze and Walker 1997, Read and Barmuta 1999). Local catchment erosion and willows are dominant features of some sections of the upper Ovens River and its tributaries and are therefore likely to influence macroinvertebrate communities throughout the study area.

The final issue that is likely to affect macroinvertebrate community composition in the study area is water quality. Different macroinvertebrate species have different tolerances to organic and other types of pollutants. Some species are very tolerant to pollutants and will persist in areas with poor water quality, but other species are very sensitive and will not survive in waters that have elevated nutrient levels, temperatures, salinity or very low dissolved oxygen. This tolerance diversity is one of the main reasons why macroinvertebrates are used as an indicator of river health. Section 7 described water quality differences throughout the upper Ovens River catchment and it may be expected that areas with poor water quality will also have degraded macroinvertebrate communities.

8.1.4 EPA monitoring 1997 – 2000.

The Victorian EPA sampled macroinvertebrate communities at 20 sites in the Forest B region and at four sites in the Highlands region of the upper Ovens River catchment. All of the Highlands region sites were on the Mt Buffalo plateau; three of these sites had very diverse and healthy macroinvertebrate communities, but the macroinvertebrate community at one site downstream of the Mt Buffalo Chalet sewage treatment plant was degraded (Miller and Barbee 2003). Most of the upper Ovens River catchment and all of the area of prime interest to this FLOWS assessment falls within the Forest B region and therefore this *Issues Paper* will focus primarily on results from this region.

Overall, the upper Ovens River supports a healthy and diverse macroinvertebrate community with most of the sampled sites meeting the SEPP (WoV) objectives the Forests B region (Table 8-1). Two of the sites on the Ovens River had degraded macroinvertebrate communities, but in both cases degradation was only detected in one habitat. The riffle habitat at Mills View Road in Reach 1, had fewer macroinvertebrate families than other sites in this reach and the overall community composition was below reference condition (Table 8-1). The Mills View Road site is located immediately downstream of a ford, and therefore the riffle substrate is likely to be regularly disturbed. Substrate disturbance is likely to have less effect on fauna in edge habitats. The macroinvertebrate community in the edge habitat of the Ovens River downstream of the confluence with Buffalo Creek was also below reference condition (Table 8-1). The low SIGNAL score indicates that pollution may be impacting the macroinvertebrate community at this site, but the riffle community at the same site had a high SIGNAL score and was equivalent to reference condition. It is more likely that willows and a lack of still or slow flowing habitats are the reason for the poor assessment at this site (Miller and Barbee 2003). Macroinvertebrate communities at several other Ovens River sites were either below reference condition or had low SIGNAL scores, but had good scores for other indices and therefore met the overall SEPP (WoV) requirements.

The most degraded macroinvertebrate communities in the upper Ovens River catchment were recorded in tributaries. The macroinvertebrate community in Roberts Creek, which joins the Ovens River near Bright, failed all of the SEPP (WoV) objectives (Table 8-1). Roberts Creek has a small catchment and there are pine plantations, an apple orchard and a dairy upstream of the monitoring site (Miller and Barbee 2003). Pollution from any of these activities may be affecting the macroinvertebrate community in Roberts Creek, but any water extraction in such a small stream is likely to have a substantial effect on flow and therefore impact the health of instream biota. Barwidgee Creek also had a poor macroinvertebrate community, with three out of the four samples failing SEPP (WoV) requirements for macroinvertebrates (Table 8-1). Barwidgee Creek has extensive cattle grazing and cropping to within 20m of the bank, non-existent or exotic riparian vegetation and an unstable substrate due to local erosion (Miller and Barbee 2003). These factors variously contribute to high nutrient levels and poor instream habitat, which both affect the macroinvertebrate community. In addition, the small size of the catchment and variable flows may reduce the ability of macroinvertebrate communities to withstand or recover from disturbances. Happy Valley Creek is prone to many of the same disturbances and impacts as Barwidgee Creek, but the one macroinvertebrate sample from this creek met all of the SEPP (WoV) objectives except for the SIGNAL index (Table 8-1). High nutrient levels have been recorded in Happy Valley Creek (Miller and Barbee 2003) and it is likely that biological monitoring at more sites would indicate a relatively degraded macroinvertebrate community in this system.

Macroinvertebrate communities in Morses Creek, the Buckland River and Buffalo Creek met the SEPP (WoV) requirements, although a lower than expected number of EPT taxa was recorded in the Buckland River (Table 8-1). The upper sections of these catchments are predominantly native forest, but the lower sections have orchards or tobacco crops and some cattle grazing. Macroinvertebrate communities in Morses Creek and the Buckland River were sampled downstream of most impacts and the relatively good condition of these communities suggest that cropping and water extraction have little effect on the biota in these two reaches. However, the macroinvertebrate monitoring site in Buffalo Creek was upstream of most of the cropping areas and water extraction points and does not necessarily provide a reliable assessment of the effect of local catchment activities.

In summary, the EPA monitoring data suggests that macroinvertebrate communities in the mainstem of the Ovens River between Harrietville and Myrtleford are generally in good or very good condition, but a number of tributaries near urban centres and in the lower part of the catchment have degraded macroinvertebrate communities. Cleared riparian zones, local catchment erosion, cattle grazing and cropping are all likely to affect the condition of macroinvertebrate communities in tributaries of the upper Ovens River. However, water extraction in these tributaries is likely to exacerbate these impacts and reduce the capacity for macroinvertebrate communities to recover from specific disturbances.

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- **Table 8-1: Summary of macroinvertebrate community data results for the Forests B region of the upper Ovens River showing compliance with SEPP (WoV) objectives. Table adapted from (EPA 2003).**

FLOWS reach	Site	Year	No. families		SIGNAL		EPT		AUSRIVAS Band		Met SEPP WoV	
			Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge
1	Ovens River at Harrietville	2000	36	27	6.6	6.4	17	13	A	B	YES	YES
	Ovens River upstream of Fish Farm	1999	34	n/a	6.6		16		A	n/a	YES	n/a
	Ovens River downstream of Fish Farm	1999	32	32	6.7	6.2	15	14	A	A	YES	YES
	Ovens River downstream of Smoko	1999	n/a	37	n/a	5.8	n/a	11	n/a	A	n/a	YES
	Ovens River at McMahons Lane	1999	25	35	6.1	6.1	11	15	B	A	YES	YES
	Ovens River at Mills View	1998	22	37	6.2	6.2	10	12	B	A	NO	YES
	Ovens River at Old Harrietville Rd	1999	32	30	6.2	5.7	14	10	A	A	YES	YES
	German Ck north of Germantown *	1998	n/a	37	n/a	6.1	n/a	13	n/a	A	n/a	YES
2	Ovens River at Bright	2000	35	31	6.1	6.2	15	12	A	A	YES	YES
	Ovens River at Braithwaite Pumping station	1998	33	31	5.8	6.2	12	12	A	A	YES	YES
	Roberts Creek at Roberts Creek Road *	1998	n/a	22	n/a	5.7	n/a	4	n/a	B	n/a	NO
3	Ovens River upstream Myrtleford (Selzers Lane)	1997	30	37	5.7	6.2	10	12	A	A	YES	YES
	Ovens River downstream Buffalo Creek	2000	26	30	6.4	5.7	12	11	A	B	YES	NO

FLOWS reach	Site	Year	No. families		SIGNAL		EPT		AUSRIVAS Band		Met SEPP WoV	
			Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge
	Ovens River downstream Myrtleford	1997	28	37	6.0	6.0	12	12	A	A	YES	YES
4	Morses Creek at Hawthorne Creek	1998	n/a	34	n/a	5.9	n/a	10	n/a	A	n/a	YES
5	Buckland River at Mt Buffalo Rd	1998	n/a	31	n/a	5.9	n/a	8	n/a	A	n/a	YES
6	Buffalo Creek at Buffalo Ck Rd	1999	37	33	6.7	6.3	17	12	A	A	YES	YES
7	Happy Valley Creek at Mudgeegonga Rd	1998	n/a	36	n/a	5.3	n/a	9	n/a	A	n/a	YES
8	Barwidgee Creek at Myrtleford Rd	1998	33	37	5.7	5.8	10	9	B	A	NO	YES
	Barwidgee Creek at Myrtleford	1998	27	31	5.4	5.7	8	8	B	A	NO	NO

AUSRIVAS BANDS:
A = Equivalent to reference condition; B = below reference condition; C = well below reference condition; D = impoverished; X = richer than reference.

* denotes sites that are tributaries of the main river assessed in each FLOWS reach

8.1.5 2004 ISC assessment

Macroinvertebrates were monitored in three reaches of the upper Ovens River catchment during the 2004 ISC assessment. This assessment gives a lower overall assessment of the condition of macroinvertebrate communities in the upper Ovens River than the broader EPA assessment, but also indicates that the health of macroinvertebrate communities generally declines from the headwaters to the downstream reaches of the catchment. The macroinvertebrate community in the Ovens River upstream of Morses Creek was given a score of 6 out of 10, indicating moderate condition (Table 8-2). Macroinvertebrate communities in the Ovens River between the Buckland River and Happy Valley Creek and in Barwidgee Creek scored 5 out of 10 and 4 out of 10 respectively, indicating poor overall condition (Table 8-2). Macroinvertebrate communities in the Ovens River upstream of Morses Creek had higher AUSRIVAS scores than communities further downstream and communities in Barwidgee Creek, but communities in all assessed reaches were considered to be below the reference condition for streams in this region (Table 8-2). Macroinvertebrate communities in the two Ovens River reaches had relatively high SIGNAL scores indicating the presence of pollution sensitive families, but the macroinvertebrate community in Barwidgee Creek had a very low SIGNAL score indicating dominance by pollution tolerant fauna (Table 8-2).

The detailed EPA assessment highlighted the variability in macroinvertebrate communities between sites within individual reaches. The differences between the broad EPA study and the ISC snapshot assessment highlight the potential problems associated with small sample sizes, although both studies demonstrated that macroinvertebrate communities in Barwidgee Creek were degraded.

- **Table 8-2 Results of ISC Aquatic Life assessment 2004 for reaches in the upper Ovens River and Barwidgee Creek (DSE 2006c).**

ISC Reach	Description	Reach length	Aquatic life index	SIGNAL (out of 4)	AUSRIVAS (out of 4)
Ovens River					
5	Ovens River between Buckland River and Happy Valley Creek	32	5	3	1
6	Ovens River upstream of Morses Creek	34	6	3	2
7	Ovens River – furthest site upstream	16	6+ Data extrapolated from Reach 6	3	2
Barwidgee Creek					
39	Barwidgee Creek – furthest site upstream	11	4	2	1
40	Barwidgee Creek – downstream of ISC Reach 39	12	4+ Data extrapolated from Reach 39	2	1

8.1.6 Effect of 2003 bushfires

A flash flood in the Buckland River one month after the January 2003 bushfires washed a slug of sediment into Ovens River. The slug moved through the catchment in a couple of days, but massive reductions in dissolved oxygen lead to a large fish kill and a fine layer of sediment covered the streambed for an extended period (DSE 2003b). The Victorian EPA sampled macroinvertebrate communities in Ovens River at Myrtleford and further downstream at Whorouly and Tarawingee in March 2003 and compared results with samples taken at these sites in autumn 2002. Results demonstrate a large reduction in the number of macroinvertebrate families, AUSRIVAS and SIGNAL scores at Myrtleford in 2003 compared with 2002 indicating a severe impact (DSE 2003b). The condition of macroinvertebrate communities at the two sites further downstream had also deteriorated compared to the 2002, but this deterioration was less severe than at Myrtleford (DSE 2003b).

The trend for a decreasing level of impact further downstream suggests that macroinvertebrate communities in the Buckland River and in the Ovens River between Eurobin and Myrtleford would have been more severely affected than the macroinvertebrate community at Myrtleford. Some fine sediment was apparent in the Buckland River during our site inspections and field assessment in 2006. However, most of the sediment slug has been flushed through the system or mixed through the substrate and persistent effects on the macroinvertebrate community are likely to be minimal. The only long lasting effect of the fires on the macroinvertebrate community would be if the sediment slug destroyed whole populations in sections of the Buckland and Ovens Rivers. Adult insects from nearby sub-catchments that were unaffected by the slug will provide colonists for the Buckland River, but the timing of this will vary for different species. Species with very mobile adults will re-colonise the affected areas more quickly than species with less mobile adult stages. Macroinvertebrate communities in the Ovens River are likely to be bolstered by adult colonists from other sub-catchments and aquatic life stages that drift into the reach from further upstream.

8.2 Effect of modified flow

The macroinvertebrate assessments discussed in this report suggest that the current flow regime has little effect on the condition of macroinvertebrate communities in the main stem of the upper Ovens River and the Buckland River. However, water extractions are likely to have a more substantial effect on summer flows in smaller catchments such as Barwidgee Creek and Happy Valley Creek than the larger rivers. Reduced summer flows in these small tributaries may exacerbate other catchment impacts such as high nutrient levels, and also reduce the quality and quantity of aquatic habitats, both of which will affect the condition of macroinvertebrate communities in these systems. Reduced flows may also decrease the capacity for established macroinvertebrate communities to recover from periodic disturbances.

The current flow regime in the upper Ovens River retains most of the key flow components that are required to sustain healthy macroinvertebrate communities. It is important that these flow components be preserved to ensure that the current condition of macroinvertebrate communities throughout the system is at least maintained.

Other non-flow related management actions that directly improve water quality, reduce erosion and reduce the dominance of willows are likely to improve the condition of macroinvertebrate communities in some parts of the catchment. The most effective management action is likely to be a combination of willow removal, native riparian revegetation and fencing to exclude stock. These actions should reduce local catchment erosion, reduce nutrient inputs, provide a more natural input of leaf litter and reduce shading during summer.

8.3 Reach condition summary

The general condition of macroinvertebrate communities and the issues affecting macroinvertebrate communities in the upper Ovens River are summarised for each of the study reaches in

- **Table 8-3: Summary of macroinvertebrate issues identified in the upper Ovens River environmental flow study reaches.**

Reach	Macroinvertebrate issues
Reach 1: Ovens River upstream of the Morses Creek confluence	**General condition** ▪ Excellent to good **Habitat:** ▪ Excellent to good **Flows:** ▪ Not flow affected **Threats:** ▪ Point source pollutants
Reach 2: Ovens River from the Morses Creek confluence to the Buckland River confluence	**General condition** ▪ Excellent to good **Habitat:** ▪ Excellent to good **Flows:** ▪ Not flow affected **Threats:** ▪ Urban impacts and point source pollutants
Reach 3: Ovens River from the Buckland River confluence to the Buffalo River confluence	**General condition** ▪ Good to moderate **Habitat:** ▪ Excellent to good **Flows:** ▪ Not flow affected **Threats:** ▪ Urban impacts ▪ Point source pollutants

Reach	Macroinvertebrate issues
	■ Diffuse nutrient inputs
Reach 4: Morses Creek	**General condition** ■ Excellent to good **Habitat:** ■ Excellent to good **Flows:** ■ Extractions may exacerbate stress on community during summer low flow period **Threats:** ■ Urban impacts and point source pollutants
Reach 5: Buckland River	**General condition** ■ Excellent to good – may be recovering from 2003 fires **Habitat:** ■ Excellent to good **Flows:** ■ Not flow affected **Threats:** ■ Point source pollutants ■ Diffuse nutrient inputs
Reach 6: Buffalo Creek	**General condition** ■ Excellent in upper reaches ■ Unknown probably moderate in lower reaches **Habitat:** ■ Good in upper reaches ■ Moderate in lower reaches **Flows:** ■ Extractions may exacerbate stress on community during summer low flow period **Threats:** ■ Nutrient inputs from crops ■ Sediment inputs from stock access to stream
Reach 7: Happy Valley Creek	**General condition** ■ Moderate to poor **Habitat:** ■ Moderate to poor **Flows:** ■ Extractions may exacerbate stress on community during summer low flow period **Threats:** ■ Stock access ■ Willows ■ Nutrient inputs ■ Catchment erosion
Reach 8: Barwidgee Creek	**General condition** ■ Moderate to poor **Habitat:** ■ Moderate to poor

Reach	Macroinvertebrate issues
	Flows: ▪ Extractions may exacerbate stress on community during summer low flow period **Threats:** ▪ Stock access ▪ Willows ▪ Nutrient inputs ▪ Catchment erosion

8.4 General macroinvertebrate management recommendations

General recommendations for managing macroinvertebrate communities in the upper Ovens River are:

3) Flow related
   a) Protect existing flow diversity (i.e current mix of seasonal high and low flows) throughout the year; and
   b) Increase summer low flows in tributaries to maintain habitat and reduce impacts associated with poor water quality and erosion.
2) Non flow related
   a) Control stock access to reduce erosion and nutrient inputs to the stream, particularly in tributary catchments;
   b) Remove willows that contribute leaf loads to the river at the 'wrong' time of year and smother aquatic habitats with dense root masses; and
   c) Reduce nutrient inputs from agricultural areas.

9. Environmental objectives

Objectives have been formulated by the EFTP for flow dependent assets in each study reach. These objectives differ from some of the management objectives and issues described in earlier sections as they specifically address flow related factors. Where factors other than flow may be limiting the achievement of objectives, complementary waterway works objectives have also been identified. In formulating objectives the EFTP considered outcomes from steering committee and community contacts meetings, past information on asset values (e.g., The North East Regional Catchment Strategy and publications noted at the beginning on Sections 4-8 of this report) and condition within each reach and observations from the site assessments undertaken on May 22-24, 2006.

For each of the listed objectives we have identified the life history stage, community response or process and the specific component and timing of the flow regime (Table 9-1) that is required to support the identified function. We have also commented on the expected response once the recommend flow regime is implemented.

Current flow patterns are very similar to the natural flow regime and many assets within the upper Ovens River are in good to excellent conditions. In most cases, degradation of aquatic assets throughout the study area is more related to weed invasion, catchment erosion, stock access and crop management than to flow changes. However, reduced summer flows in some of the tributaries are probably exacerbating some of these other impacts. Most of the flow objectives for the upper Ovens River therefore focus on protecting the current diversity and seasonality of flows in most reaches and enhancing some of the summer flows in the small tributary catchments.

Reach objectives are presented in the following tables (Table 9-2 to Table 9-9).

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■ **Table 9-1: Functions or processes supported by components of the flow regime.**

Flow component	Response function
Cease to flow *	■ Disturb lower channel features by exposing and drying sediment and bed material. ■ Promote successional change in macroinvertebrate and vegetation community composition through disturbance. ■ Maintain a diversity of ecological processes through wetting and drying.
Low flow	■ Allow accumulation and drying of organic matter in the higher areas of the channel such as benches. ■ Maintain permanent pools with an adequate depth of water to provide habitat for aquatic biota. ■ Slow the process of water quality degradation occurring in pools (avoid complete stagnation). ■ Sustain longitudinal connectivity for movement of macroinvertebrates and some fish. ■ Watering to help maintain emergent and marginal aquatic vegetation. ■ Promote recruitment for fish that spawn during low flow periods (eg carp gudgeon).
Freshes / High flow	■ Entrain terrestrial organic matter that has accumulated on bars and benches and in the upper channel. ■ Provide sediment transport. ■ Provide movement cues for fish. ■ Allow fish passage over small in-channel barriers ■ Provide flow variability to maintain species diversity of in-channel vegetation ■ Maintain vegetation zonation patterns across the channel ■ Entrainment and transport of vegetation propagules. ■ Engage flood runners within the main river channel. ■ Instigate die back of terrestrial vegetation that has encroached down the bank during the low flow period. ■ Increase habitat area available for in-channel plants and instream fauna through inundation of bars and benches and LWD located on banks.
Bankfull flow	■ Possibly provide spawning cues for fish and assist in dispersal movement. ■ Disturbance affecting in-channel and riparian vegetation, a re-setting mechanism that maintains overall plant diversity ■ Provides regeneration opportunity for riparian and floodplain species dependent on such flow events ■ Provides growth opportunity for regenerating species. ■ Transport organic matter that has accumulated in the riparian zone. ■ Instigate die back of terrestrial vegetation that has encroached down the bank during the low flow period. ■ Scour dense stands of plants (e.g. *Typha* and *Phragmites*) that have established within the main river channel. ■ Increase habitat area, including access to large woody debris and over hanging banks for instream biota. ■ Engage the riparian zone and wetlands located within the meander train.
Overbank flow	■ Engage entire floodplain, where it exists in a given reach, in order to encourage riparian vegetation regeneration and affect improved wetland wetting and drying cycles. ■ Transport organic matter that has accumulated on the floodplain and in floodplain wetlands.
Definition of terms: Cease to flow – no measurable flow in the river Low Flow – flow that provides continuous flow through the channel within that reach Freshes – small and short duration peak flow event High Flow – large flow events with longer duration than freshes, these flows cover streambed and low in-channel benches Bankfull Flow – fill the channel with little spill onto the floodplain Overbank Flow – inundate adjacent floodplain habitats. * The benefits of cease to flow events are only relevant for streams that would naturally cease to flow, imposing these flows in other systems is likely to represent a severe impact.	

■ Table 9-2: Reach 1 – Ovens River upstream of Morses Creek confluence.

Asset	Objective	No.	Function	Flow component	Timing	Expected response
Geomorphology	Maintain current hydraulic geometry	G1-1	Channel forming processes	Bankfull	Winter	■ Maintain channel form and low floodplain features as a bankfull flow in this reach will engage some flood runners.
		G1-2	Channel maintenance	Freshes / High flows	Winter	■ Maintain thalweg / channel complexity
Vegetation	Maintain the mosaic of in-channel and riparian vegetation at different states of development and so maintain diversity	V1-1	Maintain moisture in root zone of riparian plants	Low	Summer	■ Preserving flow variability and seasonal patterns will maintain the diverse vegetation community in the reach. Stable flows can encourage the establishment and persistence of non-native species; if in spring, there is a risk of favouring self seeding willow species, which will further degrade riparian zone.
		V1-2	Prevent water stress in grasses and herbs at water's edge and on low benches Provide disturbance to prevent accumulation of in-channel growths	Freshes	Summer	
		V1-3	Prevent terrestrial colonisation of bars and other channel elements	Low	Winter	
		V1-4	Disturbance to scour annuals, maintain dynamics and reset ecological processes	High	Winter	
Fish	Maintain current small bodied native fish community	F1-1	Maintain pool depth and provide some longitudinal connectivity	Low	Summer	■ Native fish in the upper Ovens are not obligate migrators, nor do they rely on high flows to trigger spawning. Maintaining flow diversity will help maintain the current diversity of native fish, particularly two-spined blackfish and mountain galaxias.
		F1-2	Maintain water quality	Fresh	Summer	
		F1-3	Protect opportunities for movement and assist movement through barriers	High	Winter / Spring	
Water quality	Maintain current water quality	W1-1	Connecting flow sufficient to maintain water quality	Low	Summer	■ The current flow elements should be protected to maintain the existing high water quality conditions.
		W1-2	Turn over pools for re-oxygenation and to oxygenate the substrate	Fresh	Summer	
Macroinvertebrates	Maintain current diverse macroinvertebrate community	M1-1	Preserve riffle habitat at all times of day and night	Low	Summer	■ The current flow diversity should be protected to maintain habitat diversity and to replenish resources underneath substrate elements to maintain the current macroinvertebrate community.
		M1-2	Disturbance to oxygenate and mix organic material through the substrate	Fresh	Summer	
		M1-3	Disturbance to turn rocks and prevent substrate from becoming tightly packed	Fresh / High	Winter	

■ **Table 9-3: Reach 2 – Ovens River from Morses Creek to the Buckland River.**

Asset	Objective	No.	Function	Flow component	Timing	Expected response
Geomorphology	Maintain current hydraulic geometry *	G2-2	Channel maintenance	Freshes / High flows	Winter	■ Maintain thalweg / channel complexity
Vegetation	Maintain the mosaic of in-channel and riparian vegetation at different states of development and so maintain diversity	V2-1	Maintain moisture in root zone of riparian plants	Low	Summer	■ Preserving flow variability and seasonal patterns will maintain the diverse vegetation community in the reach. Stable flows can encourage the establishment and persistence of non-native species; if in spring there is a risk of favouring self seeding willow species, which will further degrade riparian zone.
		V2-2	Prevent water stress in grasses and herbs at water's edge and on low benches Provide disturbance to prevent accumulation of in-channel growths Prevent terrestrial colonisation of bars and other channel elements	Freshes	Summer	
		V2-3	Prevent terrestrial colonisation of bars and other channel elements	Low	Winter	
		V2-4	Disturbance to scour annuals, maintain dynamics and reset ecological processes	High	Winter	
Fish	Maintain current small bodied native fish community	F2-1	Maintain pool depth and provide some longitudinal connectivity	Low	Summer	■ Native fish in the upper Ovens are not obligate migrators, nor do they rely on high flows to trigger spawning. Maintaining flow diversity will help maintain the current diversity of native fish, particularly two-spined blackfish and mountain galaxias.
		F2-2	Maintain water quality	Fresh	Summer	
		F2-3	Protect opportunities for movement and assist movement through barriers	High	Winter / Spring	
Water quality	Maintain current water quality	W2-1	Connecting flow sufficient to maintain water quality	Low	Summer	■ The current flow elements should be protected to maintain the existing high water quality conditions.
		W2-2	Turn over pools for re-oxygenation and to oxygenate the substrate	Fresh	Summer	
Macroinvertebrates	Maintain current diverse macroinvertebrate community	M2-1	Preserve riffle habitat at all times of day and night	Low	Summer	■ The current flow diversity should be protected to maintain habitat diversity and to replenish resources underneath substrate elements to maintain the current macroinvertebrate community.
		M2-2	Disturbance to oxygenate and mix organic material through the substrate	Fresh	Summer	
		M2-3	Disturbance to turn rocks and prevent substrate from becoming tightly packed	Fresh / High	Winter	

* This reach is predominantly bedrock controlled or under the influence of impoundment and therefore channel forming processes are not flow related over human time scales. Bank full flows will still need to occur through this reach to assist channel forming processes further downstream.

■ Table 9-4: Reach 3 – Ovens River from the Buckland River to Buffalo River confluence.

Asset	Objective	No.	Function	Flow component	Timing	Expected response
Geomorphology	Maintain current hydraulic geometry	G3-1	Channel forming processes	Bankfull	Winter	■ Floodwaters will l spill into the Happy Valley Creek before creating a bankfull flow at the field assessment site for this reach. We therefore cannot determine the magnitude of bankfull flows through this reach, but flows that spill into Happy Valley Creek will be important to maintain channel evolution – which will ultimately cause the river to avulse.
		G3-2	Channel maintenance	Freshes / High flows	Winter	■ Maintain thalweg / channel complexity
Vegetation	Maintain the mosaic of in-channel and riparian vegetation at different states of development so maintain diversity. Maintain wetland habitats	V3-1	Maintain moisture in root zone of riparian plants	Low	Summer	■ Preserving flow variability and seasonal patterns will maintain the diverse vegetation community in the reach. Stable flows can encourage the establishment and persistence of non-native species; if in spring there is a risk of favouring self seeding willows species, which will further degrade riparian zone. ■ This reach has important wetland habitats on the floodplain. High flows will deliver water to these wetlands through the gravel lens, bankfull and overbank flows will wet flood runners and flush material into wetlands and from wetlands back to the stream.
		V3-2	Prevent water stress in grasses and herbs at water's edge and on low benches Provide disturbance to prevent accumulation of in-channel growths Prevent terrestrial colonisation of bars and other channel elements	Freshes	Summer	
		V3-3	Prevent terrestrial colonisation of bars and other channel elements	Low	Winter	
		V3-4	Disturbance to scour annuals, maintain dynamics and reset ecological processes and deliver water to wetlands through gravel lens	High	Winter	
		V3-5	Fill flood runners, maintain wetlands and assist with vegetation zonation on banks	Bankfull	Winter	
		V3-6	Flush organic material into and out of wetlands	Overbank	Winter	
Fish	Maintain current small bodied native fish community (eg two-spined blackfish, river blackfish, mountain galaxias and southern pygmy perch) and rehabilitate large bodied native	F3-1	Maintain pool depth and provide some longitudinal connectivity	Low	Summer	■ Native fish in the upper Ovens are not obligate migrators, nor do they rely on high flows to trigger spawning, but high and overbank flows will facilitate movement and enhance recruitment success. ■ Maintaining flow diversity will help maintain the
		F3-2	Maintain water quality	Fresh	Summer	
		F3-3	Protect opportunities for movement and assist movement through barriers	High	Winter / Spring	

	fish community (eg Murray cod, trout cod and golden perch).	F3-4	Inundate wetlands and parts of the floodplain to promote zooplankton production and enhance larval survival and recruitment success	Bankfull / Overbank	Winter / Spring	current diversity of small native fish. ▪ Removal of downstream barriers and habitat restoration is required to facilitate rehabilitation ie. movement of Murray cod, golden perch and trout cod into Reach 3 ▪ Protection of high and flood flows will aid successful recruitment of large bodied fish if they return to this reach
Water quality	Maintain current water quality	W3-1	Connecting flow sufficient to maintain water quality	Low	Summer	▪ The current flow elements should be protected to maintain the existing high water quality conditions.
		W3-2	Turn over pools for re-oxygenation and to oxygenate the substrate	Fresh	Summer	
Macroinvertebrates	Maintain current diverse macroinvertebrate community	M3-1	Preserve riffle habitat at all times of day and night	Low	Summer	▪ The current flow diversity should be protected to maintain habitat diversity and to replenish resources underneath substrate elements to maintain the current macroinvertebrate community.
		M3-2	Disturbance to oxygenate and mix organic material through the substrate	Fresh	Summer	
		M3-3	Disturbance to turn rocks and prevent substrate from becoming tightly packed	Fresh / High	Winter	

Table 9-5: Reach 4 – Morses Creek.

Asset	Objective	No.	Function	Flow component	Timing	Expected response
Geomorphology	Maintain current hydraulic geometry	G4-1	Channel forming processes	Bankfull	Winter	■ The channel through this reach has been substantially modified through historic mining activities. Current channel form is relaxing from this impact and bankfull flows will help maintain these channel forming processes.
		G4-2	Channel maintenance	Freshes / High flows	Winter	■ Maintain channel complexity
Vegetation	Maintain the mosaic of in-channel and riparian vegetation at different states of development and so maintain diversity	V4-1	Maintain moisture in root zone of riparian plants	Low	Summer	■ Preserving flow variability and seasonal patterns will maintain the diverse vegetation community in the reach. ■ Low flows of greater importance in this reach compared to main stem of the Ovens River because of small catchment capacity.
		V4-2	Prevent water stress in grasses and herbs at water's edge and on low benches Provide disturbance to prevent accumulation of in-channel growths Prevent terrestrial colonisation of bars and other channel elements	Freshes	Summer	
		V4-3	Prevent terrestrial colonisation of bars and other channel elements	Low	Winter	
		V4-4	Disturbance to scour annuals, maintain dynamics and reset ecological processes	High	Winter	
Fish	Maintain current small bodied native fish community	F4-1	Maintain pool depth and provide some longitudinal connectivity	Low	Summer	■ Native fish in the upper Ovens are not obligate migrators, nor do they rely on high flows to trigger spawning. Maintaining flow diversity will help maintain the current diversity of native fish
		F4-2	Maintain water quality	Fresh	Summer	
		F4-3	Protect opportunities for movement and assist movement through barriers	High	Winter / Spring	
Water quality	Maintain current water quality	W4-1	Connecting flow sufficient to maintain water quality	Low	Summer	■ Water quality may deteriorate if the system ceases to flow therefore the current flow elements should be protected to at least maintain current conditions.
		W4-2	Turn over pools for re-oxygenation and to oxygenate the substrate	Fresh	Summer	
Macroinvertebrates	Maintain current diverse macroinvertebrate community	M4-1	Preserve riffle habitat at all times of day and night	Low	Summer	■ The current flow diversity should be protected to maintain habitat diversity and to replenish resources underneath substrate elements to maintain the current macroinvertebrate community.
		M4-2	Disturbance to oxygenate and mix organic material through the substrate	Fresh	Summer	
		M4-3	Disturbance to turn rocks and prevent substrate from becoming tightly packed	Fresh / High	Winter	

Table 9-6: Reach 5 – Buckland River.

Asset	Objective	No.	Function	Flow component	Timing	Expected response
Geomorphology	Maintain current hydraulic geometry	G5-1	Channel forming processes	Bankfull	Winter	■ The lower Buckland River has been substantially modified through historic mining activities. Current channel form is relaxing from this impact and bankfull flows will help maintain these channel forming processes (assessment site partially protected by bedrock control and therefore not likely to see substantial change at this site).
		G5-2	Channel maintenance	Freshes / High flows	Winter	■ Maintain thalweg / channel complexity
Vegetation	Maintain the mosaic of in-channel and riparian vegetation at different states of development and so maintain diversity	V5-1	Maintain moisture in root zone of riparian plants	Low	Summer	■ This reach has diverse in-channel habitat elements. It is important to preserve variable flows that engage and disengage habitats such as bars, benches, logs and deep pools. ■ Preserving flow variability and seasonal patterns will maintain the diverse vegetation community in the reach. Stable flows can encourage the establishment and persistence of non-native species; if in spring there is a risk of favouring self seeding willow species, which will further degrade riparian zone.
		V5-2	Prevent water stress in grasses and herbs at water's edge and on low benches Provide disturbance to prevent accumulation of in-channel growths Prevent terrestrial colonisation of bars and other channel elements	Freshes	Summer	
		V5-3	Prevent terrestrial colonisation of bars and other channel elements	Low	Winter	
		V5-4	Disturbance to scour annuals, maintain dynamics and reset ecological processes	High	Winter	
Fish	Maintain current small bodied native fish community	F5-1	Maintain pool depth and provide some longitudinal connectivity	Low	Summer	■ Native fish in the upper Ovens are not obligate migrators, nor do they rely on high flows to trigger spawning. ■ Maintaining flow diversity will help maintain the current diversity of native fish and will also ensure flow conditions are suitable for recolonisation of Macquarie perch should any future management decisions be made to stock this reach.
		F5-2	Maintain water quality	Fresh	Summer	
		F5-3	Protect opportunities for movement and assist movement through barriers	High	Winter / Spring	
Water quality	Maintain or rehabilitate current water quality	W5-1	Connecting flow sufficient to maintain water quality	Low	Summer	■ The current flow elements should be protected to maintain the existing high water quality conditions.
		W5-2	Turn over pools for re-oxygenation and to oxygenate the substrate	Fresh	Summer	
Macroinvertebrates	Maintain or rehabilitate diverse macroinvertebrate community	M5-1	Preserve riffle habitat at all times of day and night	Low	Summer	■ The current flow diversity should be protected to maintain habitat diversity and to replenish resources underneath substrate elements to maintain the current macroinvertebrate community.
		M5-2	Disturbance to oxygenate and mix organic material through the substrate	Fresh	Summer	

		M5-3	Disturbance to turn rocks and prevent substrate from becoming tightly packed	Fresh / High	Winter	

Table 9-7: Reach 6 – Buffalo Creek.

Asset	Objective	No.	Function	Flow component	Timing	Expected response
Geomorphology	Maintain current hydraulic geometry	G6-2	Channel maintenance *	Freshes / High flows	Winter	▪ Increase channel complexity
Vegetation	Maintain the mosaic of in-channel vegetation at different states of development and so maintain diversity Riparian zone is dominated by blackberries and these should be addressed before flow related issues	V6-1	Maintain moisture in root zone of riparian plants	Low	Summer	▪ Preserving flow variability and seasonal patterns will maintain the diverse vegetation community in the reach. Stable flows can encourage the establishment and persistence of non-native species; if in spring there is a risk of favouring self seeding willow species, which will further degrade riparian zone.
		V6-2	Prevent water stress in grasses and herbs at water's edge and on low benches Provide disturbance to prevent accumulation of in-channel growths Prevent terrestrial colonisation of bars and other channel elements	Freshes	Summer	
		V6-3	Prevent terrestrial colonisation of bars and other channel elements	Low	Winter	
		V6-4	Disturbance to scour annuals, maintain dynamics and reset ecological processes	High	Winter	
Fish	Maintain current small bodied native fish community	F6-1	Maintain pool depth and provide some longitudinal connectivity	Low	Summer	▪ Native fish in the upper Ovens are not obligate migrators, nor do they rely on high flows to trigger spawning. Maintaining flow diversity will help maintain the current diversity of native fish ▪ The streambed is relatively flat and it is likely that small flow reductions below a minimum summer low flow will cause large sections of the stream to quickly dry without leaving any refuge pool habitats.
		F6-2	Maintain water quality	Fresh	Summer	
		F6-3	Protect opportunities for movement and assist movement through barriers	High	Winter / Spring	
Water quality	Maintain current water quality	W6-1	Connecting flow sufficient to maintain water quality	Low	Summer	▪ The current flow elements should be protected to maintain the existing high water quality conditions.
		W6-2	Turn over pools for re-oxygenation and to oxygenate the substrate	Fresh	Summer	
Macroinvertebrates	Maintain current diverse macroinvertebrate community	M6-1	Preserve riffle habitat at all times of day and night	Low	Summer	▪ The current flow diversity should be protected to maintain habitat diversity and to replenish resources underneath substrate elements to maintain the current macroinvertebrate community. ▪ Especially important to protect summer low flows to maintain riffle and pool habitats.
		M6-2	Disturbance to oxygenate and mix organic material through the substrate	Fresh	Summer	
		M6-3	Disturbance to turn rocks and prevent substrate from becoming tightly packed	Fresh / High	Winter	

* We expect a bankfull flow to be a very rare event in this reach due to the incised channel, therefore we have not made any recommendation for a bankfull or attached any specific objectives to such a flow.

Table 9-8: Reach 7 – Happy Valley Creek.

Asset	Objective	No.	Function	Flow component	Timing	Expected response
Geomorphology	Maintain current hydraulic geometry	G7-1	Channel forming processes	Bankfull	Winter	▪ Maintain channel form especially pool – riffle sequence. Without these flows, the pools would fill with sediment.
		G7-2	Channel maintenance	Freshes / High flows	Winter	▪ Maintain thalweg / channel complexity
Vegetation	Maintain the mosaic of in-channel vegetation at different states of development to maintain diversity and rehabilitate riparian vegetation.	V7-1	Maintain moisture in root zone of riparian plants	Low	Summer	▪ Preserving flow variability and seasonal patterns will maintain the diverse vegetation community in the reach. Stable flows can encourage the establishment and persistence of non-native species; if in spring there is a risk of favouring self seeding willow species, which will further degrade riparian zone. ▪ Freshes are particularly important to flush nutrients and prevent excessive in-channel vegetation growth.
		V7-2	Prevent water stress in grasses and herbs at water's edge and on low benches Provide disturbance to prevent accumulation of in-channel growths Prevent terrestrial colonisation of bars and other channel elements	Freshes	Summer	
		V7-3	Prevent terrestrial colonisation of bars and other channel elements	Low	Winter	
		V7-4	Disturbance to scour annuals, maintain dynamics and reset ecological processes	High	Winter	
Fish	Rehabilitate small bodied native fish community	F7-1	Maintain pool depth and provide some longitudinal connectivity	Low	Summer	▪ Native fish in the upper Ovens are not obligate migrators, nor do they rely on high flows to trigger spawning. Maintaining flow diversity and improving summer flows will help improve habitat quality for small native fish.
		F7-2	Improve water quality	Fresh	Summer	
		F7-3	Protect opportunities for movement and assist movement through barriers	High	Winter / Spring	
Water quality	Rehabilitate water quality	W7-1	Connecting flow sufficient to maintain water quality	Low	Summer	▪ Higher summer low flows and freshes may help improve water quality (i.e. reduce nutrient concentrations and salinity) in this reach.
		W7-2	Turn over pools for re-oxygenation and dilute nutrients	Fresh	Summer	
Macroinvertebrates	Rehabilitate diverse macroinvertebrate community	M7-1	Preserve riffle habitat at all times of day and night	Low	Summer	▪ Summer low flows and freshes should be increased to improve water quality and improve conditions for pollution sensitive macroinvertebrate taxa.
		M7-2	Disturbance to oxygenate and mix organic material through the substrate and improve water quality in pools	Fresh	Summer	
		M7-3	Disturbance to turn rocks and prevent substrate from becoming tightly packed	Fresh / High	Winter	

Table 9-9: Reach 8 – Barwidgee Creek.

Asset	Objective	No.	Function	Flow component	Timing	Expected response
Geomorphology	Maintain current hydraulic geometry	G8-1	Channel forming processes	Bankfull	Winter	▪ Maintain channel form.
		G8-2	Channel maintenance	Freshes / High flows	Winter	▪ Maintain thalweg / channel complexity
Vegetation	Maintain the mosaic of in-channel vegetation at different states of development and so maintain diversity and rehabilitate riparian vegetation.	V8-1	Maintain moisture in root zone of riparian plants	Low	Summer	▪ Preserving flow variability and seasonal patterns will maintain the diverse vegetation community in the reach. Stable flows can encourage the establishment and persistence of non-native species, if in spring there is a risk of favouring self seeding willow species, which will further degrade riparian zone. ▪ Freshes are particularly important to flush nutrients and prevent excessive in-channel vegetation growth.
		V8-2	Prevent water stress in grasses and herbs at water's edge and on low benches Provide disturbance to prevent accumulation of in-channel growths Prevent terrestrial colonisation of bars and other channel elements	Freshes	Summer	
		V8-3	Prevent terrestrial colonisation of bars and other channel elements	Low	Winter	
		V8-4	Disturbance to scour annuals, maintain dynamics and reset ecological processes	High	Winter	
Fish	Rehabilitate small bodied native fish community	F8-1	Maintain pool depth and provide some longitudinal connectivity	Low	Summer	▪ Native fish in the upper Ovens are not obligate migrators, nor do they rely on high flows to trigger spawning. Maintaining flow diversity and improving summer flows will help improve habitat quality for small native fish.
		F8-2	Improve water quality	Fresh	Summer	
		F8-3	Protect opportunities for movement and assist movement through barriers	High	Winter / Spring	
Water quality	Rehabilitate water quality	W8-1	Connecting flow sufficient to maintain water quality	Low	Summer	▪ Higher summer low flows and freshes may help improve water quality (i.e. reduce nutrient concentrations and salinity) in this reach.
		W8-2	Turn over pools for re-oxygenation and dilute nutrients	Fresh	Summer	
Macroinvertebrates	Rehabilitate diverse macroinvertebrate community	M8-1	Preserve riffle habitat at all times of day and night	Low	Summer	▪ Summer low flows and freshes should be increased to improve water quality and improve conditions for pollution sensitive macroinvertebrate taxa.
		M8-2	Disturbance to oxygenate and mix organic material through the substrate and improve water quality in pools	Fresh	Summer	
		M8-3	Disturbance to turn rocks and prevent substrate from becoming tightly packed	Fresh / High	Winter	

10. Conclusion

Previous sections of this report have described the upper Ovens River, identified issues that are related to water and land management and set out preliminary flow related environmental management objectives based on information collected from literature, consultation and a field assessment conducted in May 2006.

Following this report, hydraulic modelling will be undertaken to relate channel morphology to streamflow. Different volumes and flow components will be run through the model to understand how the wetted area of the channel changes in relation to key habitat features identified in the field. Preliminary environmental flow recommendations will be developed and finalised in a technical EFTP workshop.

Environmental flow recommendations and catchment issues that affect the flow regime of the project area will be documented in the *Flow recommendations* paper. The *Flow recommendations* paper will detail all strategies and works, directly related to environmental water allocations, required for the project area to attain environmental objectives. It is expected that recommendations will include:

- minimum flow (in ML/d), season required, frequency (times per year or season) and duration (days);
- a scientifically defensible and clear rationale;
- indication of the impact of the current water resource development within the catchment on instream habitat, specific species and broader ecological processes;
- a discussion of the operational aspects of meeting the environmental flow recommendations; and
- suggestions for further work to fill knowledge gaps.

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Appendix A Issues identified through community consultation

Community contacts that attended the project meeting held at the Savoy Club in Myrtleford on Tuesday 9th May, 2006 identified various issues and values that they considered important to the Upper Ovens River, but that were not necessarily being addressed through this environmental flows assessment. The following issues were raised at the Community Contacts meeting held at the Savoy Club in Myrtleford on Tuesday 9th May 2006:

Fish

- Recreational trout fishing is a significant activity in the upper Ovens River and associated tributaries and there was concern that environmental flows were not being developed to benefit this species.
- Environmental flows that enhance fish movement may have little effect if fish passage through existing barriers is not addressed.

Water resource management issues

- Urban water authorities intend to build large water storages
- The river offers important opportunities for water sports such as kayaking, canoeing and swimming etc.
- There are social benefits (e.g. gourmet food tourism and winery visits) to the region due to agriculture that rely on irrigation.
- Water is used for snow making in the catchment during winter.
- There was concern that the flow recommendations would not take account of drought conditions and would therefore impose unrealistic restrictions on irrigators during dry years.
- There was concern that recent fires and pine plantations would substantially affect modelled flows and therefore bias flow recommendations for the Upper Ovens River.
- Alpine moss beds were raised as a potentially important in storing and releasing water into the Upper Ovens River catchment and that threats or changes to these moss beds could have a substantial effect on future flow patterns.

Other issues associated with river health

- There was a concern that the removal of willows would reduce fish habitat and increase water temperatures in the Ovens River and its tributaries. This was considered to be of greatest threat to trout.