



# **Environmental Flow Determination for the Gellibrand River**

## **SITE PAPER**

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# Environmental Flow Determination for the Gellibrand River

## SITE PAPER

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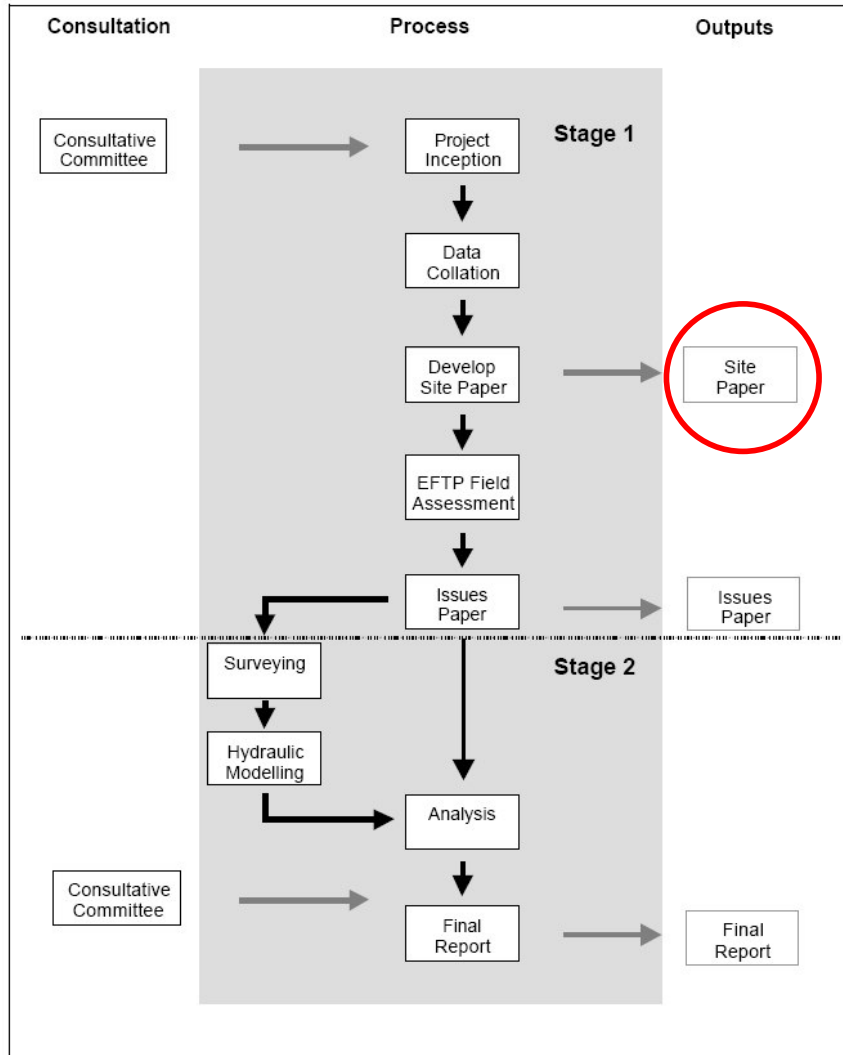
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# 1 Introduction

This Site Paper describes the rationale for selection of reach breaks throughout the Gellibrand River catchment, including the major tributaries and the estuary, for the investigation into the environmental flow requirements for these reaches. Identification of river reaches and representative sites is the first stage in application of the FLOWS method for assessment of environmental water requirements as highlighted in Figure 1-1.

**Figure 1-1 Outline of the FLOWS methodology**



Reaches have been characterised based on consideration of the following attributes:

- Geomorphology and geology – channel and floodplain morphology.
- Hydrology – major tributaries, storages, extractions and gauging station locations.
- Land use.
- Riparian vegetation.
- Aquatic biota.

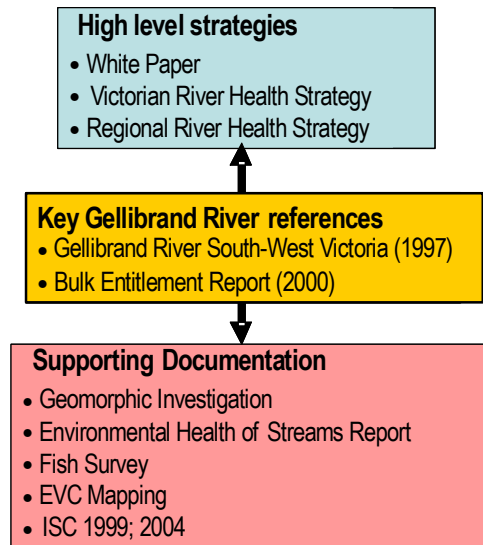
Reach breaks are generally located such that each of these attributes are relatively consistent within each reach. For each reach, a minimum of one representative site will be identified to assist in characterisation of the features of the reach and in the two major stages of the FLOWS method; objective setting and development of recommendations.

The assessment of the above attributes has been based on a review of available mapping and published reports. The discussion presented in this Site Paper departs slightly from the FLOWS method as it contains a comprehensive literature review. Greater detail regarding the representative sites will be provided in the **Issues Paper** to be released later in the course of the environmental flow assessment.

## 2 Literature Review

There are many documents relating to the Gellibrand River catchment, ranging from high level policy to specific condition investigations (eg. regional river health strategies to flow stress investigations to geomorphic studies). The following Literature Review captures the key elements of documents that focus on the flow related issues within the catchment. The structure of the review is shown in Figure 2-1 and further explained below.

**Figure 2-1 Schematic explanation of literature review structure with examples of key 'flow-related' documents**



High Level Strategies: includes State policy and regional plans that detail strategic Government policy direction and form high level guides and approaches for Victorian catchments.

Key References: consists of the flow related documents. These are specific to the Gellibrand River catchment and inform much of the understanding of the flow related issues in the catchment.

Supporting Documentation: includes documents that provide an understanding of the condition of the Gellibrand River. However, these documents do not address stream health issues from a flow dependent perspective.

## High Level Strategies

### **Securing Our Water Future Together – Victorian Government White Paper (2004) Department of Sustainability and Environment (DSE)**

This document outlines the current State Government initiatives for water management throughout Victoria. Among these initiatives, the White Paper recognises the need for long term water use planning to ensure security of supply for human usage and for environmental flows. As a component of this, an Environmental Water Reserve (EWR) will be established to enable the ecological objectives for all river and groundwater systems to be achieved.

### **Victorian River Health Strategy (2002) Department of Natural Resources and Environment (now DSE)**

The Victorian River Health Strategy provides strategic direction and targets for improving the health of rivers, streams and floodplains to ensure environmental, economic, recreational and cultural needs of current and future generations are met. The Strategy outlines a planning framework based on community decision-making within an integrated catchment management context. A key component of this Strategy is the establishment of a series of Regional River Health Strategies.

### **Corangamite River Health Strategy (2004) Corangamite CMA**

The Corangamite River Health Strategy emphasises the need to manage rivers as a whole integrated system and not just for economic, social and environmental outcomes. The vision for the future encompasses four main goals for river health, namely:

- Water quality and quantity.
- Instream habitats.
- Streamside vegetation.
- Physical form.

The Otway Basin, in particular, is considered to have the following values:

- **Environmental**  
The Otway Basin holds a vast array and number of different species of birds, mammals, reptiles, amphibians and fish. Two of the fish species are listed as threatened and three are protected.
- **Social**  
Fishing, camping, swimming, boating and bushwalking are all popular activities in the Otway Basin.
- **Economic**  
There are six proclaimed water supply catchments in the Basin. In addition, there has been a boost in tourism and residential developments.

Major threats to the Otway Basin include increased pressure on water supplies, degradation of riparian vegetation caused by weeds instream, instream barriers to fish migration and poor water quality.

## Key Gellibrand River References

Due to the significance of the Gellibrand River and its catchment, there have been numerous environmental flow studies completed.

### **Environmental Flow Recommendations For the Gellibrand River South-West Victoria (1997)**

#### **Barry Tunbridge**

The Gellibrand River and its tributaries are acknowledged to have a high conservation value due to the following attributes:

- Large population of River Blackfish (*Gadopsis marmoratus*) and other native species. River Blackfish are most abundant in the middle reaches from Newling to Mt McKenzie.
- The relatively 'natural' state of some reaches.
- Active geomorphic processes that have contributed to good instream structure (natural).

It is noted that in 1997 river diversions were not significantly impacting on aquatic biota in the Gellibrand River, despite causing quite a large reduction in flow in summer and in dry and drought years. River Blackfish and other biota respond to the following conditions, with respect to flow:

- 150-250 ML/day gives excellent conditions for breeding and resting for River Blackfish and other biota in general.
- 70 ML/day maintains 60-97% of rearing and resting habitat and most spawning sites used by the River Blackfish and keeps an 85% wetted perimeter. This is the minimal environmental flow.
- 20 and 30 ML/day in the North and South Otway Pipelines, respectively, maintains 40-85% of habitats usable by River Blackfish. Flows below this level are increasingly detrimental to the availability of habitat.

As such, the following flow regime was recommended under the existing licences:

- Restrictions initiated when flow falls to below 28ML/d, progressive reductions until a minimum of 10ML/day is reached
- Arkins Creek- Minimum environmental flow 2.5ML/day in summer months
- Carlisle River- Minimum environmental flow 5.5ML/day in summer months
- Flow downstream of the South Otway Pipeline- no restrictions until flow falls to 20ML/day where a sharing arrangement will be instated until there is a minimum flow of 10ML/day.

#### *River Geomorphology*

The Gellibrand River passes through unstable Cretaceous sandstone and mudstone. As such, slumping in surface soil often occurs, causing a shallow single channelled river with uniform width and steep, unstable banks with a sand substrate.

Common geomorphic features include gutters, holes and channels. These formations create excellent habitat for River Blackfish and other aquatic biota.

Banks in the middle reaches are well vegetated and the steepness of the slopes has prevented some livestock access, which in many instances has preserved bank structure. However, stock have trampled down some banks causing sedimentation to form a sandbank across the width of the channel. Tunbridge (1997) states that the greatest threat to these values comes from bank destruction and debris removal.

### **A study of environmental flows necessary to maintain fish populations in the Gellibrand River and Estuary (1988)**

#### **B.R. Tunbridge and T.J. Glenane**

Proposals to extract extra water from the Gellibrand River for increased domestic usage initiated an investigation into the impact this would have on existing, high value fish populations. Therefore in different sections of the river, hydraulic measurements were taken to relate changes in quantity of fish to changes to flow. The following requirements were considered:

- All fish should be able to pass freely along the river during the year.
- At least 10% of the bankfull width should be maintained with a depth greater than 20cm.
- The velocity of flow at the bottom of the channel should be less than 50 cm/sec.

In the case of the Gellibrand River, these requirements are met with a minimum flow of 25 ML/day, which occurs only in drought years. The following requirements, however, should also be considered when determining a flow regime:

- Logs in the Gellibrand River are potential spawning sites for River Blackfish if the water depths are greater than 24cm above the site, and velocities are less than 10cm/s.
- A water temperature of 16 degrees Celsius is required for reproduction and a daytime temperature of 13-24 degrees Celsius is needed for the incubation of eggs.
- Flows of 70-128 ML/day have maintained 75% of all spawning sites in a usable condition for River Blackfish.
- Rearing habitat for River Blackfish and trout are areas of substrate with water more than 45cm deep and velocities no greater than 30cm/sec. These areas are also suitable for platypus (*Ornithorhynchus anatinus*) and Lamprey ammocetes rearing except, a velocity of less than 15cm/sec is needed.
- Flows of 50-100 ML/day allowed 60-85% of rearing habitat in the Gellibrand.
- Resting habitat for aquatic biota requires a water depth of no less than 45cm and velocities of up to 15cm and 30cm per second for adult River Blackfish and Brown Trout (*Salmo trutta*) respectively.

As such, three levels of flow were determined; optimum, minimum and survival. They are defined respectively as follows:

- Optimum flow maintains at least 90% of different types of fish habitat, passage and wetted perimeter and should be implemented when natural flows or rainfall are above and after a short period of survival flow.

- Bunkers Hill 150 ML/day, 38% of mean annual natural flow.
- Carlisle 150-200 ML/day, 34% of mean annual natural flow.
- Burrupa 140 ML/day, 15% of mean annual natural flow.
- Minimum environmental flow maintains at least 70% of different types of fish habitat, 10% passage and 80% wetted perimeter and should be implemented when river flows and rainfall are typical.
  - Bunkers Hill 65-90 ML/day, 19% of mean annual natural flow.
  - Carlisle 50 ML/day, 13% of mean annual natural flow.
  - Burrupa 50 ML/day, 5% of mean annual natural flow.
- The survival environmental flow maintains at least 50% of different types of fish habitat, 10% passage and 60% wetted perimeter and should be implemented only in the case of drought.
  - Bunkers Hill, 11% of mean annual natural flow.
  - Carlisle, 9% of mean annual natural flow.
  - Burrupa, 5% of mean annual natural flow.

The Gellibrand estuary is a salt-wedge type with a shallow sand bar that restricts the entrance. When high flows occur, the estuary becomes totally fresh and during times of low flow the entrance can close and cause the stagnation of the salt water and an increase in hydrogen sulphide in deeper holes.

A freshes program must be implemented to flush out anoxic water from the estuary, thereby preventing and removing any blocking salt wedge as follows:

- 2000 ML/day for three days, three times a year.

It is recommended, however, that further study should be conducted into:

- The timing and duration of flushing flows, especially if there is to be increasing diversions.
- The extent to which bream and perch move between the sea and estuary, and their respective salinity requirements.

### **Environmental flows and fish populations of waters in the South-Western Region of Victoria (1988)**

#### **B. R. Tunbridge**

The recommendations for the Gellibrand River were the same as the above paper.

### **Gellibrand River Streamflow Management Plan (1998)**

#### **Southern Rural Water**

The Streamflow Management Plan was completed in order to create a sustainable sharing of resources between stakeholders along the Gellibrand River. Recommendations are as follows:

- The Gellibrand River System should be divided into three management zones under the streamflow management plan.
  - **Zone 1** The Gellibrand River and tributaries from a suitable gauging site approximately 100m downstream of the NOPL (North Otway Pipeline), to the ocean.
  - **Zone 2** The Gellibrand River, from the proposed gauging site below the NOPL (approximately 100m downstream), upstream to Asplin Creek, to include all tributaries except Zone 3.
  - **Zone 3** The Carlisle River system, upstream of its junction with Rusty Creek including all tributaries.
- Flow share for Zone 1 is divided between urban and irrigator users and the environment. Flow is from the North and South Otway pipelines
- Flow share for Zone 2 is divided between urban and irrigator users and the environment. Flow is from the North Otway Pipeline.
- Flow share for Zone 3 is as follows: a minimum flow of 2 ML/d at the Rusty Creek gauging station. If committed supplies of water lessen in the future then, this minimum flow should be increased accordingly.

### **Fish Populations and Environmental Flows in the Gellibrand River and Love Creek South Western Victoria. (1996)**

**Brenton Zampatti, Emma Bradshaw and Kylie Lewin prepared for the Southern Rural and South-West Water.**

This report was compiled as a follow-up from the Tunbridge and Glenane environmental flow study (1988). It examines fish populations, habitat availability, and environmental water requirements in the Gellibrand River and Love Creek Catchment. It aims to find a baseline flow, for the summer months, because it is believed that the Love Creek Catchment supplies a relatively large proportion of this flow from the Kawarren aquifer. Proposals to extract groundwater could reduce annual and summer flows by 20 and 28% respectively.

Water is diverted from the Gellibrand River via three pipelines. Continued population growth has meant that the Otway water supply system is nearing its capacity. The pipelines supply water to the towns of Warrnambool, Camperdown, Colac, Simpson, Cobden, Lismore, Derrinallum, Terang, Noorat, Glenormiston and Allansford.

Conclusions made from the study, with respect to the Gellibrand River, were:

- Fish assemblage in the Gellibrand above Stevenson's Falls is more diverse than previous study had found.
- Brown Trout exclude or reduce the population levels of Mountain and Broad-finned Galaxiids (*Galaxias brevipinnis*) in Upper Gellibrand Catchment and Love Creek Catchment.
- Eastern Gambusia (*Gambusia holbrooki*) species may also decline the population levels of small native fish.
- River Blackfish numbers were less than those reported by Zampatti and McGuckin in 1995. However more investigation is recommended.

- Until maximum habitat maintenance flows are found from flow habitat relationships, recommended minimum instantaneous discharges for the Gellibrand River and Love Creek have been derived from historical flow records (Shown below).
- Periodic flushing is also recommended to prevent siltation and the de-oxygenation of the salt wedge in the Gellibrand Estuary.
- Recommended discharges for the Gellibrand were specified at three gauging stations; Upper Gellibrand, Bunker Hill and Burrupa.

Table 5-2 Recommended minimum instantaneous discharges for sites on the Gellibrand River.

Gauging Station	50th Percentile Flow (ML/d)*											
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Upper Gellibrand	14.0	8.0	7.0	12.0	36.2	84.8	132.0	156.9	130.0	91.0	54.3	30.0
Bunker Hill	69.4	51.3	52.0	65.5	114.8	230.1	431.0	520.9	447.1	288.6	175.1	112.5
Burrupa	147.2	105.7	116.6	173.0	291.0	583.7	1164.9	1414.0	1298.0	707.0	422.0	251.9

\*To be measured at respective hydrographic gauging stations

- Recommended discharges for the Love Creek Catchment were specified as follows:

Table 5-1 Recommended minimum instantaneous discharges for creeks in the Love Creek Catchment.

Site	50th percentile flow (ML/d)*											
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Ten Mile Ck	2.0	1.8	1.8	2.0	2.5	3.5	4.6	6.0	6.0	4.7	2.7	2.2
Porcupine Ck	1.4	0.9	0.9	1.8	3.4	9.5	15.2	25.6	21.3	12.6	4.4	1.9
Yahoo Ck	1.1	1.1	1.1	1.3	1.4	2.4	4.6	10.0	7.0	3.4	1.4	1.2
Love's Ck	3.5	2.8	3.1	5.5	8.1	15.2	30.9	47.4	37.9	19.3	9.5	6.3

\* To be measured at respective hydrographic gauging stations

## Supporting Documents

### **Otway System Realm Model Development (1997)**

#### **Southern Rural Water South West Water. Department of Natural Resources and Environment.**

The purpose of this study was to develop a model of the Gellibrand River and Otway water supply system. This was completed by adjusting an existing REALM model of the Otway system developed for Southern Rural Water in 1993. The completed model would be used to determine variables which determine bulk water entitlements for surface water diversions under present demands.

The conclusions reached were as follows:

- The length of the irrigation season in the Gellibrand Catchment varies greatly and is dependent on the amount and timing of rainfall.
- Diverters' licences have only been rationed rarely during low flow events. The majority of diverters are dairy farmers.
- The catchment characteristics and limited human resources make the prevention of unlicensed water use difficult.
- For licensed users, the lowest demand was approximately 400 ML in 1993/94 which was a relatively wet season and a high demand of 820 ML in the 1996/97 irrigation season which corresponded to very dry conditions.
- The charging system for both licensed diverters and sporadic licences changed after the 1994/95 irrigation season to a charge per mega litre plus a fixed service charge per licence.
- The rural diverter community requested to be involved in future decision making with regards to the management of the Gellibrand catchment.

### **Evidence to the Parliamentary Public Works Committee: Gellibrand River Inquiry (1981)**

#### **State Rivers and Water Supply Commission Victoria**

This paper was prepared as evidence on behalf of the State Rivers and Water Supply Commission to investigate the possibilities for groundwater recharge in the Gellibrand River Basin, and in particular the question of land resumption for recharge works.

Conclusions reached with respect to the Gellibrand and Bunker Hill sites were as follows:

- Major storage construction should not occur at either site.
- Construction of low weirs at or near these sites to impound water only within river bank height might be required in connection with groundwater recharge.

The hydrogeology of the Gellibrand and Bunker Hill storage basins are also described:

- Considerable quantities of good quality water are stored in unconsolidated sandy sediments beneath the storage basins of the dam sites. The sediments are known as the Wangerrip Group and are of Lower Tertiary age. The sediments are excellent

aquifers and are hydraulically connected to the Gellibrand River over most of its course including Lardner and Charleys Creeks and perhaps Love Creek.

- Streamflow analysis during prolonged dry periods and some observations of groundwater levels suggest that the Gellibrand River and its tributaries are fed from the groundwater aquifers during non-high flow events.

**The Environmental Conditions of Victorian Streams (1990)**  
**Philip Mitchell, for the Department of Water Resources, Victoria**

This report is the first of a series of reports that present the results of the State of the Streams Survey Data. It is an assessment of the environmental condition of streams and rivers in Victoria.

With respect to the Otway Basin, and in particular the Gellibrand River, the report concludes the following:

- The upper reaches of the Gellibrand River near the Upper Gellibrand township are in excellent condition.
- Sites further downstream on the Gellibrand River range from good to moderate.
- The tributaries of the Gellibrand vary from excellent (Chapple Creek) to moderate or poor (Porcupine Creek), due to pastured banks.
- Land west of the Gellibrand is predominantly cleared. Curdies River and the tributaries and Campbell Creek range from moderate to poor condition with willows or pasture lining the waterway.

**River Health Monitoring Of the Gellibrand Catchment and the Thomson, Wimmera and Glenelg Basins - Final Report (1999)**  
**Department of Natural Resources and Environment**

This report presents data regarding the monitoring and assessing of river health across five Victorian basins (Thomson, Werribee, Otway, Wimmera and Glenelg) the major objectives are as follows:

- To provide regular river health data thereby giving an early warning of ecological disturbance.
- Measure and evaluate the success of relative catchment management strategies.
- To encourage active management.

With respect to the Gellibrand Catchment the following was concluded:

- The health of the catchment was found to be of similar condition to that previously measured.
- The allocation of adequate environmental flows to ensure an increase in habitat heterogeneity or at least preservation is required.
- Levels of Nitrogen and Phosphorus are still of concern at Love Creek where algal growth has depleted habitat.

## **Survey of angling and recreation use of the Gellibrand River, South-Western Victoria (1984)**

**John Koehn**

A survey of angling and recreation was undertaken on the Gellibrand River during the 1982-83 freshwater River Blackfish open fishing season. The number of river users were counted in terms of Recreational Day Units. Thirteen fish species were identified in the freshwater reaches of the Gellibrand River.

### *Survey sections*

- **Upper** - Stephenson's Falls (13km from river source) is steep forested country which then becomes farming areas, downstream with more access points.
- **Middle** - patchy regions of farmland and tracks with many reaches difficult to access.
- **Lower** - roadway traces the river path but banks are steep and scrubby.
- **Estuary** - estuarine wetlands. Vegetation dominated by Common Reed (*Phragmites australis*), Rush (*Juncus spp.*) and Club-Rush (*Scirpus spp.*).

In general, the agricultural regions are floodplains, that have been cleared. Dominant agricultural use is dairy cattle grazing. Riparian vegetation is predominantly Willows and Blackberries with Blackwood and various Eucalypts. The river is generally less than 10m wide.

The very upper reaches of the Gellibrand are deep and narrow valleys with steep banks. Eucalypt forests of Mountain Ash, Mountain Grey Gums and Messmates dominate with several areas of pine plantations.

## **Biological Monitoring in the Gellibrand River Catchment (1998)**

**Alistair Cameron and Danny Vertessy for the Department of Natural Resources and Environment and Southern Rural Water.**

The major objectives of this study were to:

- Provide information on river health as an early warning of ecological disturbance.
- Measure success of catchment management programs.
- Compare this catchment with other systems.
- Provide information from the predictive model to assist with river management planning.
- Improve and strengthen the predictive model.
- Encourage active management.
- Evaluate the flow assessment criteria proposed by Tunbridge and Gleane (1988) and recommend environmental flows to protect aquatic biota.

The following conclusions and recommendations were established:

- Biological monitoring should continue on the Gellibrand River and at Bunkers Hill.

- Water and land managers should implement plans which improve instream habitat, including reducing stock access to streams.
- Nutrient levels need to be reduced.
- Recommended flow levels as stipulated by Zampatti and co-workers (1996) should be adhered to until a more comprehensive study is undertaken and further emphasis is placed on the habitats of the aquatic biota in the Gellibrand River.

### **A survey of the flora and fauna in four catchments of the Gellibrand River basin, Otway Ranges, Victoria (1986)**

**G.E. Earl, A.F. Bennett**

This report consists of a presentation of the results of an intensive vegetation survey, and short term faunal survey within four catchments of the Gellibrand River Basin.

- Carlisle River.
- Charleys Creek.
- Lardner Creek.
- Upper Gellibrand River.

Selection of sites was based on the following criteria:

- Vegetation communities identified in a primary floristic survey of the Otway Shire was the main basis for site selection.
- Sites were representative of a number of different habitat types.
- Sites were located away from observable ecotones.
- Sites were dispersed appropriately.
- Regions of agricultural land use were not sampled.

The following conclusions were made:

- There is a diverse array of flora in the Gellibrand River basin which in turn supports a diverse array of fauna.
- The floral and faunal habitat values of the four waterway catchments listed above are ranked as follows (from most to least valuable): Carlisle River, Upper Gellibrand River, Lardner Creek and Charleys Creek.

## 3 Catchment Overview

The Gellibrand River catchment is situated in south west Victoria, within the Otway Coast Basin. The river headwaters rise on the northern face of the Otway Ranges. The river travels southwest to the township of Gellibrand, then west to Bunker Hill before turning south-west to flow through alluvial terraces and floodplains and enter the Southern Ocean near Princetown. The total catchment area is approximately 1200km<sup>2</sup> and consists of eucalyptus forests and cleared grazing land for beef and dairy cattle. Major tributaries include Love Creek, Lardner Creek, Carlisle River, Kennedys Creek and Chapple Creek.

### Upper Catchment

The crest of the Otway Ranges has relatively low topography, reflecting the initial flat-topped structural block before recent uplift. This moderately dissected plateau forms a drainage divide, from which the headwaters of the Gellibrand River flow to the north. Key land uses include production and plantation forestry, grazing and nature parks.

The Gellibrand's upper catchment is one of the wettest parts of Victoria, with an average annual rainfall of 2040 mm (Barton & Sherwood, 2004). River water is used by the Colac District Water Board and for the Water Supply System, which supply towns from Camperdown to Warrnambool.

After flowing through steep terrain covered with eucalypt forests, the river meanders through predominantly agricultural land and across extensive flood plains. Throughout agricultural areas, the river is used extensively for irrigation, particularly during summer.

### Lower Catchment

The Gellibrand River enters the coast in the Twelve Apostles Marine National Park, near Princetown. The estuary is a salt-wedge type, with little mixing between fresh and sea water. The upper estuary floodplain is approximately 1 km wide, and is mostly cleared and drained for dairy pasture. The Princetown wetlands (VIC093), which cover an area of 119 hectares, have national recognition in the directory of important Australian wetlands (Barton & Sherwood, 2004).

## 4 Catchment Characteristics

The Gellibrand catchment has been widely modified since European settlement (Cameron & Vertessy, 1998). The upper reaches consist of wet sclerophyll forest and remnant areas of cool temperate rainforest. However extensive areas of the middle and lower reaches have been cleared for grazing land, although remnant areas of wet sclerophyll forest remain. Most of the Gellibrand River suffers from some degree of disturbance, with one or both sides of the bank having been cleared for agriculture, or the bank vegetation having been modified by the introduction of exotic plants or by cattle.

**Table 4-1 – General Statistics of the Gellibrand River System**

<b>Catchment area</b>	1200 km <sup>2</sup> (Zampatti <i>et al.</i> , 1996)	
<b>Elevation range</b>	300 - 400 metres elevation in the headwaters of the Upper Gellibrand. Most of the catchment is between 50 and 150 metres above sea level.	
<b>Average Annual Diversion</b>	14,000 ML (Zampatti <i>et al.</i> , 1996)	
<b>Urban and Industrial Uses</b>	Grazing of dairy and beef cattle is the dominant form of land use in the catchment (298km <sup>2</sup> of grazing land).	
<b>Storage</b>	West Gellibrand Dam	2000 ML (Zampatti <i>et al.</i> , 1996)
	Olangolah Weir	136 ML

The Gellibrand catchment is situated in a high rainfall area, with average rainfall varying from 800mm in the northern section, to 1800mm in the south-eastern corner of the catchment. Mean annual flow, recorded at Burrupa in the Lower Gellibrand, is 315,000 ML (329,000 ML unregulated).

Water is diverted from the Gellibrand River via three pipelines. The main two pipelines are the (north) Otway Main Pipeline, which off takes water from both Arkins Creek and the Gellibrand River downstream of Carlisle River, and the South Otway Pipeline, which off takes from the junction of the Gellibrand River and Kennedys Creek. In the headwaters of the Gellibrand, a third pipeline diverts water from the West Gellibrand Dam (2,000 ML capacity) and Olangolah Weir (136 ML capacity) to Colac. Annual diversions from these storages are estimated at 3,300 ML. A further 9,000 ML/annum is diverted through the Otway water supply system, plus an estimated 1,704 ML/annum from direct irrigation extractions from the Gellibrand River (total extractions approximately 14,000 ML/annum).

The Gellibrand River is considered the best River Blackfish waterway in Victoria, in terms of both number and size of fish. The catchment has a high diversity of aquatic macroinvertebrates and generally the health of the catchment is good. It has a high natural variability in flow conditions and the natural low habitat heterogeneity contributes to the community structure within the basin.

## Geology of the Gellibrand Catchment

On both sides of the Otway divide, rugged topography has developed, comprising ridges and spurs separated by deeply dissected steep valleys. The drainage is strongly controlled by the geological structure. The streams flowing south are mostly short and enter the sea directly, where those to the north join the larger Barwon and Gellibrand river systems. Soils vary from shallow stony loams in the steep and actively eroding parts of the landscapes, to brown and tallow gradational soils with associated colluvium on the slopes. Thick deposits of colluvium and landslide debris are common.

The Gellibrand River flows through extensive areas of Quaternary alluvial deposits of sand, silt, clay and gravels. Tertiary sediments and Cretaceous sandstone and mudstone are also present. Slumping of surface soil material is common in the unstable lower Cretaceous sediments, which has created a shallow single-channelled river of uniform width, unstable steep banks and sand substrate (Tunbridge & Glenane, 1988). The water has low salinity, high iron, phosphate and nitrate concentrations, is well aerated and has a turbidity of 30 NTU during high flows.

## Stream Condition

Index of Stream Condition (ISC) assessments were undertaken in the Gellibrand catchment in 1999 and in 2004. The ISC scores for the Gellibrand River system show significant variation in condition along the length of the river. Both the 1999 and 2004 surveys rated the catchment as generally marginal.

A discussion regarding the condition of each of the 5 ISC sub-indices (hydrology, physical form, streamside zone, water quality and aquatic life) is provided in the following section.

**Table 4-2 1999 ISC Scores for the Otway Basin**  
(Source: Victorian Water Resources Data Warehouse <http://www.vicwaterdata.net/vicwaterdata>)

\* Data not directly available. Sub-index score calculated on the basis of other sub-index scores (pro rata)  
+ sub-index score estimated by EPA

Rating	Number of Reaches	% Length	Reaches
Excellent	3	8%	<b>18*</b> , <b>25*</b> , <b>31*</b>
Good	5	14%	<b>5*</b> , <b>14</b> , <b>21*</b> , <b>26*</b> , <b>33*</b>
Marginal	17	38%	<b>1*</b> , <b>6*</b> , <b>7*</b> , <b>13</b> , <b>15*</b> +, <b>16</b> , <b>17</b> , <b>19*</b> , <b>22*</b> , <b>23*</b> , <b>24</b> , <b>27*</b> , <b>29*</b> , <b>30*</b> , <b>34*</b> , <b>35*</b> , <b>36*</b>
Poor	9	22%	<b>2</b> , <b>3*</b> , <b>4*</b> , <b>8*</b> , <b>9*</b> , <b>11*</b> , <b>12*</b> , <b>20*</b> , <b>37*</b>
Very Poor	0	0%	

Note – **bold** indicates a reach of the Gellibrand River or tributary

**Table 4-3 1999 ISC scores for sites within the Gellibrand River (location of sites 12–25 are shown on Figure 5-1)**

\* Data not directly available. Sub-index score calculated on the basis of other sub-index scores (pro rata)  
 + sub-index score estimated by EPA

Stream Name	Reach	Hydrology	Physical Form	Streamside Zone	Water Quality	Aquatic Life	Total	Condition
Gellibrand River	12	7	8	2	-	-	25*	Poor
Gellibrand River	13	7	4	5	9	9	29	Marginal
Gellibrand River	14	8	6	7	9	10	37	Good
Gellibrand River	15	9	5	6	6+	-	30*+	Marginal
Gellibrand River	16	7	3	6	9	10	29	Marginal
Muree Creek	17	7	7	4	6	8	29	Marginal
Muree Creek	18	10	9	8	-	-	44*	Excellent
Chapple Creek	19	10	8	2	-	-	28*	Marginal
Sandy Creek	20	10	5	3	-	-	25*	Poor
Carlisle Creek	21	10	6	10	9	-	41*	Good
Unnamed Creek (Gum Gully Creek)	22	10	4	8	-	-	32*	Marginal
Lardner Creek	23	10	4	2		10	26*	Marginal
Love Creek	24	10	6	4	8	9	32	Marginal
Love Creek	25	10	9	8	-	-	44*	Excellent

**Table 4-4 2004 ISC scores for sites within the Gellibrand River**

Stream Name	Reach	Hydrology	Physical Form	Streamside Zone	Water Quality	Aquatic Life	Total	Condition
Gellibrand River	12	4	6	3	-	6	21	Marginal
Gellibrand River	13	4	4	7	5	5	23	Marginal
Gellibrand River	14	7	4	4	5	8	24	Marginal
Gellibrand River	15	7	3	3	5	10	22	Marginal
Gellibrand River	16	7	6	8	9	9	36	Good
Muree Creek	17	5	7	5	3	5	22	Marginal
Muree Creek	18	5	6	6	-	-	28	Marginal
Chapple Creek	19	9	8	7	-	-	39	Excellent
Sandy Creek	20	9	6	9	-	-	38	Excellent
Carlisle Creek	21	6	5	8	8	6	30	Good
Unnamed Creek (Gum Gully Creek)	22	10	4	9	-	-	34	Good
Lardner Creek	23	9	5	3	-	-	24	Marginal
Love Creek	24	6	6	8	3	-	25	Marginal
Love Creek	25	6	6	10	-	-	34	Good

## Hydrology

### General Statistics

The Gellibrand River has a mean annual regulated flow of 315,000 ML (recorded at Burrupa), however annual flows vary considerable. Flows are highest during April and lowest during March, and in many years the ratio of highest to lowest mean monthly flows can be as much as 20 to 1 (Tunbridge & Glenane, 1988). A feature of the Gellibrand is the rapidity of change in flows and the variation between daily flows, particularly during the high-flow period, June to November.

Two flow regimes have been suggested in the literature for the preservation of fish habitat within the Gellibrand, depending on natural flows and rainfall (Tunbridge & Glenane, 1988). The first is a minimum flow that should be maintained continuously when natural flows and rainfall are approximately average (65 ML/day at Bunkers Hill, 70 ML/day at Carlisle and 50 ML/day at Burrupa for all months). The second flow regime is based on minimal optimum flows (150 ML/day at Bunkers Hill, 200 ML/day at Carlisle and 140 ML/day at Burrupa for all months).

The estuary is a salt-wedge type and is highly stratified with little mixing between fresh and sea water. The inflow of fresh water controls the upstream location and size of the salt wedge, although saline water may extend up to 10 km upstream from the mouth of the river. During high flows in winter and spring the estuary becomes totally fresh, while at times of low flow, a salt wedge is present and reaches its maximum upstream limit. Flows between 1500-2300 ML/day are required to remove the salt wedge from the estuary, and it can only return when flows decrease to 750 ML/day.

### Available Hydrologic Data

The five key stream gauges along the Gellibrand River from upstream to downstream are:

- Gellibrand River at Upper Gellibrand (235202)
- Gellibrand River at Bunkers Hill (235227)
- Gellibrand River at Carlisle River Pump Station (235225)
- Gellibrand River downstream of the South Otway Pump Station (235258)
- Gellibrand River at Burrupa (235224)

There are a further three key stream gauges within the Gellibrand River catchment:

- Love Creek at Gellibrand (235234)
- Lardner Creek at Gellibrand (235210)
- Kennedys Creek at Kennedys Creek (235211)

Additional information on these active gauges, as well as an additional nine (9) inactive gauges throughout the catchment can be found in Table B1 in Appendix B.

## Physical Form

### Upper Catchment

Above the township of Gellibrand, the Gellibrand river has a mean width of 4 metres, with long stretches of very shallow water (60 cm deep) and occasional pools of up to 2 metres in depth. Downstream of Gellibrand, the river has a mean width of 10 metres, which is consistent along most of the remaining 85 kilometres of freshwater. The channel is of uniform size and shape in its middle and lower reaches.

During the low flow period in summer, pools in the middle reaches of the river reach a maximum depth of 2 metres and are up to 3 metres deep in the lower reaches, around Burrupa. Large areas of shallow riffles predominate in the upper reaches of the river, although pools (depth greater than 1 metre) make up 60% of the area of river in the middle reaches and 89% in the lower reaches.

### Estuary

The Gellibrand River enters the Southern Ocean near Princetown. The estuary opens to the east of the high cliffs at Point Ronald, cutting across a sand bar that is approximately 150 metres wide, with a typical channel width of 25 to 30 metres, and a channel depth of 1 to 1.5 metres. Upstream, the channel broadens to up to 50 metres wide and 3 metres deep, with occasional deeper scour holes at bends, and with wide floodplains. The upper part of the estuary narrows to approximately 3.5 km from the mouth becoming 6 to 20 metres wide and 5 to 7 metres deep, and with narrow floodplains, and levee banks beside the channel (Barton *et al.*, 2004).

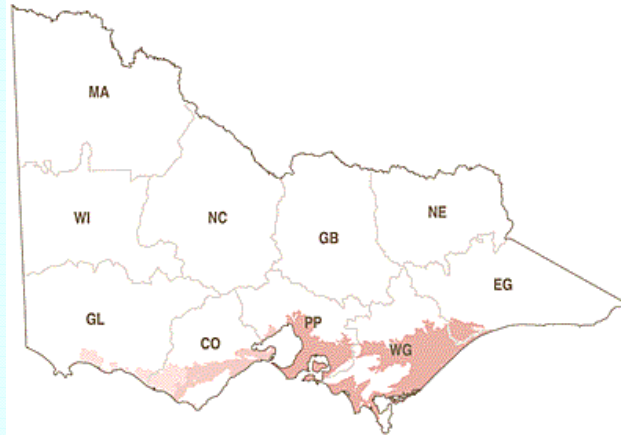
## Streamside Zone

### Bioregions of the Gellibrand Catchment

The Gellibrand River basin traverses two bioregions:

- Otway Plain, and
- Otway Ranges.

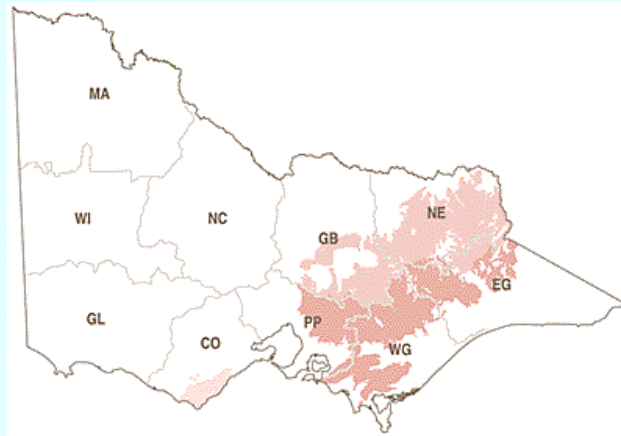
The Department of Primary Industries (DPI) provides the following description of these bioregions:



(source: <http://www.nre.vic.gov.au/plntanml/biodiversity/directions/plains.htm>)

**Otway Plain** includes coastal plains and dunes, foothills with river valleys and swamps in the lowlands. Ridges mark the positions of successive shorelines associated with the long-term retreat of the sea. The soils associated with the upper terrain are texture contrast soils (Chromosols and Sodosols) and gradational texture soils (Dermosols), supporting Lowland Forest and Heathy Woodland ecosystems. The dunes are predominantly sandy soils (Podosols and Tenosols) and the floodplains and swamps are earths and pale yellow and grey texture contrast soils (Hydrosols) supporting predominantly Grassy Woodland and Plains Grassy Woodland ecosystems.

(source: [http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/veg\\_managemt\\_otway\\_plain](http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/veg_managemt_otway_plain))



(source: <http://www.nre.vic.gov.au/plntanml/biodiversity/directions/highland.htm>)

**Otway Ranges** consists of moderate to steep slopes, deeply dissected blocks of alternating beds of sandstone, siltstone and shales, and swampy alluvial fans in the lowlands. The geology is of Mesozoic non-marine deposits covered with a veneer of younger Cainozoic deposits at lower elevations. Brown earths and brown texture contrast soils (Chromosols, Kurosols and Sodosols) occur throughout the bioregion with leached sands (Podosols) in the lowlands.

(source: [http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/veg\\_managemt\\_otway\\_ranges](http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/veg_managemt_otway_ranges))

## Ecological Vegetation Classes – Gellibrand River Catchment

Priority Ecological Vegetation Classes (EVCs) for the Otway Plains include Grassy Woodland, Swampy Riparian Woodland, Floodplain Riparian Woodland, Grassy Forest and Plains Grassy Woodland. Swampy Riparian Woodland are a priority EVC for the Otway Ranges.

Gellibrand estuary once had a varied mosaic of EVCs and seems to have kept at least a small example of each. EVC mapping for the estuary has identified vegetation consistent with Coastal Due Scrub (EVC 1), Estuarine Wetland (EVC 10), Swamp Scrub (EVC 53) and Floodplain Reedbed (EVC 863) (Barton *et al.*, 2004).

## Water Quality

Based on results of water quality analysis at three sites in the Gellibrand catchment, Vertessy *et al.* (1999) describe water temperatures ranging from 9.6°C at Love Creek (Site 235 234) to a maximum of 18°C at the Gellibrand River at Burrupa (Site 235 224). The highest stream temperatures were generally observed at the most downstream site at Burrupa, whilst the lowest stream temperatures were generally observed at Love Creek.

Dissolved oxygen (DO) concentrations measured by Vertessy *et al.* (1999) indicate well-oxygenated water. Concentrations generally complied with the ANZECC (1992) guideline for the protection of aquatic ecosystems of greater 6.0 mg/L and the SEPP (1998) criterion of 5.0 mg/L, and therefore DO is not expected to be limiting to the presence of aquatic macroinvertebrates in the long term.

Electrical conductivities recorded for the Gellibrand River (Vertessy *et al.*, 1999) do not indicate a discrete pattern in the catchment. Love Creek at Gellibrand (Site 235 234), the most upstream site in the study, had higher EC readings than the Gellibrand River sites on all sampling occasions. All readings obtained from the catchment were below the ANZECC (1992) guideline for the protection of aquatic ecosystems of 1,500 µS/cm and are not expected to be limiting to the presence of aquatic macroinvertebrates. Cameron *et al.* (1998) report a general trend which indicates that conductivity increases in a downstream direction.

Monitoring of pH within the Gellibrand catchment indicates that many of the sites are naturally acidic (Cameron & Vertessy, 1998). Many of the sites show a natural wide variation in pH, from very acidic to very alkaline. All pH measurements for the Gellibrand catchment were above the Victorian Government (1988a) objective of 6.0, but several measurements, including most pH readings taken at the downstream site at Burrupa, failed to comply with the ANZECC (1992) guideline for the protection of aquatic ecosystems of 6.5 pH units.

Turbidity in the Gellibrand catchment is generally associated with flow variation, and hence, rainfall, as is typical of riverine systems. At either the beginning of peak flow periods or at the peak of flow, there is commonly an increase in turbidity levels above ANZECC guidelines for the protection of aquatic ecosystems (Cameron & Vertessy, 1998). However, turbidity results are generally low, and are lowest in the upper reaches of the Gellibrand River and in tributaries including West Arkins Creek, Lardner Creek and Chapple Creek (Cameron & Vertessy, 1998). Readings are marginally higher in Love Creek at Gellibrand (Gauge Site 235234) than at the other sites in the catchment. As there is a high percentage of sand and silt in the Gellibrand catchment sediments, and the catchment shows a naturally high variation in flow, the maximum allowable increase of 25 NTU is recommended for this catchment. Turbidity is not expected to be limiting to the macroinvertebrate community structure (Vertessy *et al.*, 1999).

Nutrient levels in the Gellibrand catchment are above the ANZECC (1992) guidelines for the protection of aquatic ecosystems at all sites, except the pristine West Arkins Creek (Cameron & Vertessy, 1998). This is therefore likely to impact upon the structure and functioning of the biotic communities. As land use at all other sites examined in the catchment is dominated by agriculture and any urbanisation within the catchment is small, anthropogenic sources of nutrients are expected to be diffuse and results from agricultural surface runoff and fertiliser application. Nutrient enrichment can lead to excessive macrophyte and algal growth.

Total phosphorus water quality guidelines for the protection of aquatic ecosystems are dependent on water hardness, and range between 0.01 mg/L for soft water and 0.1 mg/L for hard water (ANZECC, 1992). Cameron *et al.* (1998) report all readings in the Gellibrand catchment were above the guidelines, except for those measured at Arkins Creek West and Chapple Creek at Chapplevale, indicating potential nutrient impacts.

The pattern of salinity in the catchment is predictable, with generally an increase in salinity in a downstream direction. There is a decrease in salinity at downstream sites which are immediately below tributaries with low salinity concentrations (Cameron & Vertessy, 1998).

## Aquatic Life

The Gellibrand River carries the best population of River Blackfish of any river in Victoria and possibly in south-east Australia, both in number and size of fish. It also contains a higher percentage of large River Blackfish than any other water yet surveyed in Victoria. Large fish (greater than 24cm) comprise 33% of the population present in the Gellibrand, compared to only 12 and 16% in rivers such as the Yarra and Thomson, both considered to be good River Blackfish waters.

The Gellibrand River, including its main tributary the Carlisle River, contains 12 species of native fish and only one species of introduced fish (Brown Trout). The Pouched Lamprey (*Geotria australis*) and the Broad-finned Galaxias (*Galaxias brevipinnis*) are also reportedly present. This type of faunal assemblage is uncommon in rivers in Victoria (Tunbridge & Glenane, 1988). Most freshwater rivers and lakes are dominated by introduced salmonids, European Carp (*Cyprinus carpio*) or Redfin Perch (*Perca fluviatilis*) and have less than four species of native fish present.

The Gellibrand catchment has a high diversity of aquatic macroinvertebrates compared to other basins across Victoria (Cameron & Vertessy, 1998). Macroinvertebrate species richness has been observed to decline in a longitudinal pattern, from headwater streams to lowland rivers, which is consistent with other macroinvertebrate surveys. Major impacts on macroinvertebrate fauna include loss of instream habitat, removal of native vegetation and turbidity in high flows (Cameron & Vertessy, 1998).

## 5 Reach Breaks

Using the FLOWS methodology, reach breaks are allocated based on system operation and broad changes or significant values of the 5 ISC sub-indices (hydrology, hydrology, physical form, streamside zone, water quality and aquatic life). According to FLOWS, the following should be considered when selecting reach breaks:

- Location of major tributaries.
- Channel morphology and structure.
- Floodplain morphology and structure.
- Presence of key habitats of value.
- System operation.
- Flora and fauna structure and value.

Accordingly, the catchment can be segregated in a number of ways based solely on each index. Generally, reach breaks are allocated to capture the greatest number of these changes, whilst remaining manageable for the FLOWS assessment.

### Proposed Reach Breaks for the Gellibrand Catchment

There are a number of ways to separate the Gellibrand catchment. Due to the hydrologic focus of this environmental flow study and the homogeneous nature of the catchment land use, particularly in the lower reaches, reach breaks have been proposed based primarily on the hydrology. As such, three of the reach breaks are sub-catchments of the Gellibrand, namely Love Creek, Kennedys Creek and Carlisle River catchments. Many of these breaks do, however, match the separations proposed according to other ISC indices, as summarised in Table 5-1.

The proposed reach breaks are shown in **Error! Reference source not found.** and detailed in Appendix A. Appendix A provides information on:

- Major tributary inputs within each reach.
- The typical condition and dominant management issues within each reach.
- Key access points within the reach.
- Likely requirements for survey (to be undertaken at a representative site within the reach).

**Table 5-1 Proposed Reach Breaks for the Gellibrand Catchment**

Reach No.	Hydrology	Physical Form	Streamside Zone	Water Quality	Aquatic Life	Surrounding Land Use
1 <b>Love Creek Catchment</b>	Major tributary to Gellibrand River. Highly variable flows, which respond rapidly to rain events. Baseflow primarily groundwater derived.	Upstream: 2-2.5m wide, <0.5m deep. Yahoo Creek confluence: 3-4m wide, occasional pools. Arkuna: Series of large rocky pools, 5-6m wide, <1m deep. Downstream: 2-3m high banks, deep pools 4-5m wide.	Riparian zone dominated by grasses with some willows and blackberries. Some sites highly degraded with minimal streamside vegetation. At other sites, streamside vegetation relatively intact.	Nutrient enrichment (N and P) has lead to excessive macrophyte and algal growth. Water clarity decreases in downstream sites.	Significant fish assemblages and unique co-existence of Galaxiid species. Introduced Brown Trout present (notable in Ten Mile Creek). Significant River Blackfish stocks at downstream sites. Lack of instream habitat.	Predominantly rural use zone (dairy pasture) with some remnant wet sclerophyll forest.
2 <b>Upper Gellibrand River</b>	Headwaters rise on northern face of Otway Ranges. Colac pump extracts flow upstream.	Series of deep rocky pools downstream of Stevensons Falls. Mean width of 4m above township of Gellibrand. 12m wide with steep banks at Bunkers Hill. Generally lacks riffle habitat.	Minimally disturbed wet sclerophyll forest downstream of West Gellibrand Reservoir. Riparian zone dominated by exotic vegetation, particularly willows and blackberries. Relatively intact riparian vegetation at Bunker Hill.	High sediment load and deposition. Nutrient enrichment has lead to excessive macrophyte and algal growth near confluence with Lardner Creek.	Broad-finned Galaxiids, Brown Trout, Short Finned Eels, Flat-headed Gudgeons and Eastern Gambusia. River Blackfish above Stevensons Falls. Relatively high abundance of aquatic invertebrates.	Undisturbed wet sclerophyll forest and cool temperate rainforest in upper reaches. Conifer plantations in parts of catchment. Cleared grazing land from Bunkers Hill.
3 <b>Carlisle River Catchment</b>	Major tributary to Gellibrand River.	Channel width downstream of Arkins Creek up to 6m with sand and mud substrate. Pool depth varies from 80-150cm.	Willows and replanted native vegetation. Valuable floral and faunal habitat.		Contains River Blackfish, Short Finned Eel, Brown Trout, Short Headed Lamprey, Spotted Galaxias and Common Galaxias.	Wet sclerophyll forest and cool temperate rainforest in upper reaches. Cleared land for agriculture and plantations.

Reach No.	Hydrology	Physical Form	Streamside Zone	Water Quality	Aquatic Life	Surrounding Land Use
<b>4</b> <b>Gellibrand River Mid Reach</b>	Gellibrand River from Carlisle River confluence to estuary reach (Great Ocean Rd). Flow diversions near Leahy and Kennedys Creeks for Main and South Otway pipelines (approx. 9,000 ML/annum).	Uniform channel size and shape in middle and lower reaches (10-13m wide with steep banks and sand substrate). Westwick Track: 10m wide with series of deep pools (>2m) joined by shallower (1-1.5m) sandy runs. Banks 2-3m high. Burrupa: 10m wide and mostly greater than 2m deep. Mildly sinuous channel, with steep banks.	Areas of relatively undisturbed riparian vegetation. Cleared vegetation and grazing down to the water line around Burrupa. Riparian zone consists mainly of introduced pasture grasses and sparse tree and shrub vegetation. Extensive bank erosion around South Otway pumping station.	Nutrient enrichment (N and P) from agricultural runoff and uncontrolled stock access.	Significant River Blackfish populations. Increase in aquatic macrophytes at Burrupa. Minimal aquatic vegetation.	Predominantly rural land use, cleared for grazing.
<b>5</b> <b>Kennedys Creek Catchment</b>	Major tributary to Gellibrand River.	Representative River of dissected coastal plains, volcanic plains.	High percentage of exotic vegetation, consisting of willows, blackberries & pasture grasses.	Low water level for part of the year, with high water temperatures and low dissolved oxygen concentrations. Potential for salinity impacts.	Contains small Brown Trout, common galaxias, Short Finned Eel, Spotted Galaxias, Broad Finned Galaxias, Flat Headed Gudgeon and Australian Grayling.	Predominantly rural use zone. Land has been largely cleared on western site of catchment.
<b>6</b> <b>Gellibrand River Estuary</b>	Salt-wedge type estuary. Limited mixing between fresh and sea water. Saline water extends approximately 10km upstream from mouth.	Upstream of Coxons Rd bridge: deep (>2m) and channelised (5-10m wide). Estuary: typical channel width of 25-30m, depth 1-1.5m. Further upstream channel broadens up to 50m (3m deep) with wide floodplain.	Upstream of Coxons Rd bridge: floodplain cleared and grazed down to river on both banks. Princetown wetlands near confluence with Boggy Creek.	Salt water influx during low flow. Stagnant anoxic water on the bottom when entrance bar is closed and no salt water enters.	Important Princetown Wetlands, with significant numbers of Swamp Greenhood. Three conservation plants (Swamp Greenhood, Ruddy Bent and Coast Stackhousia) and one listed fish species (Pouched Lamprey) in estuary.	Predominantly environmental rural use zone. Some public conservation and research.

## Hydrology

Three of the six reach breaks described in Table 5-1 have been located at major sub-catchment confluences. The Love Creek, Kennedys Creek and Carlisle Creek catchments all contribute significant flow sources to the Gellibrand system.

The upper Gellibrand and estuary reaches are relatively easily defined based on hydrology. The former incorporates the smaller headwaters flowing from the northern face of the Otway ranges, and the upper reaches of the Gellibrand as far as the confluence with Carlisle Creek. The estuary reach flows from the Great Ocean Road to the mouth of the river near Princetown, and is characterised by tidal influences and the movement of a salt-wedge upstream from the river mouth.

The mid Gellibrand River reach from the confluence with Carlisle River to the Great Ocean Road is defined based on alterations to streamflow at the two pumping stations for the Otway Main and South Otway pipelines, located at the confluence with Leahy and Kennedys Creeks, respectively. Diversions at these pipelines total 9,000 ML/annum, plus an estimated 1,704 ML/annum from direct irrigation extractions from the river.

## Physical Form

There is limited systematic geomorphic information on the catchment to devise reaches on the basis of geomorphic characteristics and behaviour such as channel and floodplain morphology and structure.

The three tributary reaches identified have generally smaller channel size (width and depth) than the Gellibrand river channel. Love Creek varies from 2 - 6 metres in width, with some areas containing large rocky pools less than one metre deep. Similarly, the Carlisle River has a channel width of up to 6 metres, with pool depths up to 1.5 metres.

In the headwaters of the catchment, the upper Gellibrand River has a mean width of only 4 metres, although widens into a relatively uniform channel (size and shape) throughout the middle and lower reaches, ranging from 10 to 13 metres in width, with steep banks. The downstream section of the estuary reach is characterised by a broad channel and wide floodplain.

## Streamside Zone

Division of this system according to streamside zone is primarily based on forested and agricultural land uses. However, most of the Gellibrand River suffers from some degree of disturbance, with one or both sides of the bank having been cleared for agriculture, or the bank vegetation having been modified by the introduction of exotic plants (e.g. willows) or by cattle. The main exception is the upper reaches of the catchment, which retains minimally disturbed and undisturbed wet sclerophyll forest.

## Water Quality

Nutrient enrichment due to agricultural runoff and stock access to the river is a common problem throughout the catchment, and as such, water quality is not a significant factor in determining the location of reach breaks.

The estuary displays distinctly different water quality based on the influx of salt water during low flow, and the extension of the salt wedge 10 km upstream from the mouth of the river. The estuary can also become stagnant and anoxic when the entrance bar is closed and no salt water enters.

### **Aquatic Life**

There are significant fish assemblages through the Gellibrand catchment. The river supports the best population of River Blackfish in Victoria, which have been identified in most reaches.





### **Map of Proposed Reach Breaks for the Gellibrand Catchment – Appendix C**



## 6 References





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## Appendix A Reach Descriptions

Note: Site numbers in the following tables are referenced to photo locations on the catchment map in Appendix C.









<b>Reach One: Love Creek Catchment</b>	
<b>Description</b>	Love Creek upstream of the confluence with Gellibrand River
<b>Major tributaries</b>	<ul style="list-style-type: none"> <li>Ten Mile Creek</li> <li>Porcupine Creek</li> <li>Yahoo Creek</li> </ul>
<b>Potential access points</b>	<ul style="list-style-type: none"> <li>Wonga Road (off Colac Beech Forest Road)</li> <li>Road and access track 250 metres north of Wonga Road</li> </ul>
<b>Assessment and survey requirements</b>	<ul style="list-style-type: none"> <li>FLOWS assessment</li> <li>Survey required</li> </ul>
<b>Issues/condition</b>  (based on description of a site near Stevenson Falls, as described by Cameron & Vertessy, 1998)	<ul style="list-style-type: none"> <li>Highest number of taxa of any of the sites examined in the Gellibrand catchment.</li> <li>Riparian zone dominated by grasses with some willows and blackberries.</li> <li>Surrounding land use associated with grazing.</li> <li>No instream vegetation.</li> <li>Riffle habitat limited because of a high percentage of bedrock.</li> <li>Impacts of water quality affect aquatic invertebrate colonisation.</li> <li>Potential for salinity impacts.</li> <li>Nutrient enrichment has lead to excessive macrophyte and algal growth.</li> </ul>
	
<b>P1 - Ten Mile Creek Gauge (235239)</b>	<b>P1 – Ten Mile Creek, looking downstream at Cashings Rd</b>
	
<b>P2 – Love Creek, looking downstream, near Karwarren</b>	<b>P2 – Love Creek, looking upstream, near Kavarren</b>



<b>Reach Two: Upper Gellibrand to the Carlisle River Confluence</b>	
<b>Description</b>	Upper Gellibrand River from headwaters to confluence with Carlisle River (including upper tributaries).
<b>Major tributaries</b>	<ul style="list-style-type: none"> <li>• Charleys Creek</li> <li>• Lardner Creek</li> <li>• Asplin Creek</li> <li>• Olangolah Creek</li> <li>• Barramunga Creek</li> <li>• Gum Gully Creek</li> <li>• Boggy Creek</li> </ul>
<b>Potential access points</b>	<ul style="list-style-type: none"> <li>• Larsons Road off Carlisle North Road.</li> <li>• Silks Road off Carlisle North Road.</li> <li>• Gaines Road off Carlisle North Road.</li> <li>• Carlisle North Road at Black Bridge.</li> <li>• Greens Road off Gellibrand Road.</li> <li>• Access track from Gellibrand township.</li> </ul>
<b>Assessment and survey requirements</b>	<ul style="list-style-type: none"> <li>• FLOWS assessment</li> <li>• Survey required</li> </ul>
<b>Issues/condition</b>  (based on description of sites near Stevenson Falls, Lardners Track and Bunker Hill, as described by Cameron & Vertessy, 1998)	<ul style="list-style-type: none"> <li>• Relatively good water quality and instream macrophyte habitat.</li> <li>• Riparian zone consists of predominately exotic vegetation, particularly willows and blackberries.</li> <li>• Lacks riffle habitat and there is a high contribution of sand in the substrate.</li> <li>• Relatively high abundance of aquatic invertebrates.</li> <li>• Impacted by the clearing of riparian vegetation.</li> <li>• Nutrient enrichment has led to excessive macrophyte and algal growth near confluence with Lardner Creek.</li> <li>• Relatively intact riparian vegetation at Bunker Hill, with riparian zone extending into forest cover.</li> </ul>
	
<b>P5 – Gellibrand River, looking upstream at bridge off Lardners Road</b>	<b>P6 – Gellibrand River, looking upstream off track near Lardners Road</b>



<b>Reach Two: Upper Gellibrand to the Carlisle River Confluence</b>	
	
<b>P4 – Lardner Creek, looking upstream at weir, Gauge (235210) at Lardners Road</b>	<b>P3 – Gellibrand River, looking downstream from Colac-Beech Forest Road bridge</b>
	
<b>P7 – Charleys Creek, looking upstream from Carlisle-Gellibrand Road bridge</b>	<b>P8 – Gellibrand River, looking downstream at Bunkers Hill Gauge (235227)</b>





Reach Three: Carlisle River Catchment	
<b>Description</b>	Carlisle River upstream of the confluence with Gellibrand River, upstream of the Otway Main Pipeline pumping station.
<b>Major tributaries</b>	<ul style="list-style-type: none"> <li>Cole Creek</li> <li>Camp Creek</li> <li>Arkins Creek</li> </ul>
<b>Potential access points</b>	<ul style="list-style-type: none"> <li>Gellibrand River Road / Carlisle North Road</li> <li>Larsons Roads (and access tracks) off Carlisle North Road</li> <li>Access track off Moomowroong Road, Carlisle River township</li> </ul>
<b>Assessment and survey requirements</b>	<ul style="list-style-type: none"> <li>FLWS assessment</li> <li>Survey required</li> </ul>
<b>Issues/condition</b>	<ul style="list-style-type: none"> <li>Exemplary stands of wet sclerophyll forest and cool temperate rainforest.</li> <li>Two rare plant species, <i>Cyathea cunninghamii</i> and <i>Oxalis magellanica</i> found in Arkins Creek.</li> <li>A wide diversity of faunal habitats ranging from <i>Eucalyptus regnans</i>-dominated tall open-forest through a variety of mixed-species forests to heathy woodland on sand soils.</li> </ul>
	
<b>P9 - Carlisle River, looking upstream from Gellibrand River Road bridge</b>	<b>P9 - Carlisle River, looking upstream from Gellibrand River Road bridge</b>

<b>Reach Four: Gellibrand River - Carlisle River Confluence to the Estuary (Great Ocean Rd)</b>	
<b>Description</b>	Gellibrand River from confluence with Carlisle River (upstream of Otway Mine Pipeline pumping station) to Great Ocean Road.
<b>Major tributaries</b>	<ul style="list-style-type: none"> <li>Leahy Creek</li> <li>Sandy Creek</li> <li>Chapple Creek</li> <li>Jones Creek</li> <li>Atkinson Creek</li> </ul>
<b>Potential access points</b>	<ul style="list-style-type: none"> <li>Alexanders Road (crosses Gellibrand River upstream of Otway Main Pipeline pumping station)</li> <li>Montys Track off Gellibrand River Road</li> <li>Westwicks Road off Gellibrand River Road</li> <li>King Track off Gellibrand River Road</li> <li>Deans Road off Gellibrand River Road</li> <li>Access track at Burrupa (off Gellibrand River Road)</li> </ul>
<b>Assessment and survey requirements</b>	<ul style="list-style-type: none"> <li>Flows assessment</li> <li>Survey required</li> </ul>
<b>Issues/condition</b>  (based on description of sites downstream of the Carlisle River pumping station, at the South Otway pumping station and at Burrupa, as described by Cameron & Vertessy, 1998)	<ul style="list-style-type: none"> <li>Lacks riffle habitat.</li> <li>Surrounded by predominantly native vegetation, apart from the presence of blackberries.</li> <li>Benthic invertebrates would be susceptible to disturbance under high flow conditions due to high percentage of sand in substrate</li> <li>Riparian vegetation includes <i>Ranuncululus</i>, <i>Polygonum</i> and submerged <i>Triglochin</i>.</li> <li>High percentage of snags and some associated build up of shallow sandbars downstream of Carlisle River pumping station.</li> <li>Contains common invertebrates found throughout catchment.</li> <li>Extensive bank erosion evident around South Otway pumping station.</li> <li>Limited habitat near the South Otway pumping station may be restricting the diversity of macroinvertebrates at this site.</li> <li>Riparian zone at Burrupa consists mainly of introduced pasture grasses and sparse tree and shrub vegetation.</li> <li>Increase in aquatic macrophyte at Burrupa.</li> </ul>

	
<p><b>P10 – Gellibrand River at the North Otway Pipeline pump station.</b></p>	<p><b>P10 – Gellibrand River, upstream of the North Otway Pipeline offtake from Alexanders Road</b></p>
	
<p><b>P11 – Chapple Creek, looking upstream from Gellibrand River Road</b></p>	<p><b>P12 – Gellibrand River at the Lavers Hill Road bridge</b></p>
	
<p><b>P14 – Gellibrand River, looking d/stream from the Gellibrand River Rd bridge</b></p>	<p><b>P14 – Gellibrand River, looking upstream from the Gellibrand River Road bridge</b></p>
	
<p><b>P16 – Gellibrand River, looking upstream from the Great Ocean Road bridge</b></p>	<p><b>P16 – Gellibrand River, looking downstream from the Great Ocean Road bridge</b></p>

Reach Five: Kennedys Creek Catchment	
<b>Description</b>	Kennedys Creek upstream of the confluence with Gellibrand River at the South Otway Pipeline pumping station.
<b>Major tributaries</b>	<ul style="list-style-type: none"> <li>Muree Creek</li> <li>Tomahawk Creek</li> <li>Danger Creek</li> </ul>
<b>Potential access points</b>	<ul style="list-style-type: none"> <li>Access track off Lavers Hill Cobden Road, upstream of Kennedys Creek Telephone Exchange</li> <li>Kennedys Creek Road (crosses Kennedys Creek)</li> </ul>
<b>Assessment and survey requirements</b>	<ul style="list-style-type: none"> <li>FLOWS assessment</li> <li>Survey required</li> </ul>
<b>Issues/condition</b> <small>(based on description of a site near Cobden/ Simpson Road Bridge, as described by Cameron &amp; Vertessy, 1998)</small>	<ul style="list-style-type: none"> <li>High percentage of exotic vegetation, consisting of willows, blackberries and pasture grasses.</li> <li>The diversity in the pool habitat was enhanced through the presence of trailing <i>Polygonum</i> and floating <i>Triglochin</i>.</li> <li>The riparian zone was covered with <i>Juncus</i> which is expected to increase invertebrate habitat in higher flow periods.</li> <li>Potential for salinity impacts.</li> </ul>
	
<p><b>P13 - Kennedys Creek at the Kennedys Creek Gauge (235211), track off Kennedys Creek Road</b></p>	<p><b>P13 - Kennedys Creek at the Kennedys Creek Gauge (235211), track off Kennedys Creek Road</b></p>

<b>Reach Six: Gellibrand River Estuary</b>	
<b>Description</b>	Gellibrand River downstream from the Great Ocean Rd to Southern Ocean outlet, near Princetown.
<b>Major tributaries</b>	<ul style="list-style-type: none"> <li>• Latrobe Creek</li> <li>• Boggy Creek</li> </ul>
<b>Potential access points</b>	<ul style="list-style-type: none"> <li>• Princetown Reserve Road off Great Ocean Road, southeast of Princetown (downstream access point)</li> <li>• Access roads off Old Ocean Road, including Coxons Road</li> <li>• Access track off Great Ocean Road (upstream access point)</li> </ul>
<b>Assessment and survey requirements</b>	<ul style="list-style-type: none"> <li>• FLOWS assessment</li> <li>• Survey required</li> </ul>
<b>Issues/condition</b> (based on Barton & Sherwood, 2004)	<ul style="list-style-type: none"> <li>• Princetown Wetlands are of national significance.</li> <li>• Extensive beds of Common Reed, and meadows dominated by Beaded Glasswort that can support large numbers of waterbirds.</li> <li>• Significant numbers of Swamp Greenhood occur in wetland.</li> <li>• Three conservation listed plants (Swamp Greenhood, Ruddy Bent and Coast Stackhousia) and one listed fish species (Pouched Lamprey) in Gellibrand estuary.</li> <li>• Estuary catchment has been cleared, drained and is used for grazing, resulting in the reduction in the amount and diversity of vegetation types.</li> </ul>
	
<b>P17 – Gellibrand River estuary, looking downstream from near Princetown</b>	<b>P17 – Gellibrand River estuary, looking upstream from near Princetown</b>

<b>Reach Six: Gellibrand River Estuary</b>	
	
<b>P18 – Gellibrand River estuary, looking downstream from Princeton Reserve Road</b>	<b>P18 – Gellibrand River estuary, looking upstream from Princeton Reserve Road</b>
	
<b>P19 – Gellibrand River mouth at Point Ronald, looking west</b>	<b>P19 – Gellibrand River mouth at Point Ronald, looking west</b>

# Appendix B Stream Gauges

**TABLE B1 – GELLIBRAND RIVER STREAM GAUGES (ACTIVE AND INACTIVE)**

Source: Victorian Water Resources Data Warehouse

Site Code	Site Name	Site Status	Contractor	Begin Date	End Date	No. of Records
<a href="#">235202</a>	<a href="#">GELLIBRAND RIVER @ UPPER GELLIBRAND</a>	Active	WES	11-Apr-05	13-Jul-05	<a href="#">4</a>
<a href="#">235227</a>	<a href="#">GELLIBRAND RIVER @ BUNKERS HILL</a>	Active	WES	12-Apr-05	14-Jul-05	<a href="#">4</a>
<a href="#">235225</a>	<a href="#">GELLIBRAND RIVER AT CARLISLE RIVER (PUMPING STATION)</a>	Active	THIESS	1-Jan-99	1-Jan-01	<a href="#">3</a>
<a href="#">235258</a>	<a href="#">GELLIBRAND RIVER D/S SOUTH OTWAY PUMPS BRIDGE</a>	Active	THIESS	1-Jan-99	1-Jan-01	<a href="#">3</a>
<a href="#">235224</a>	<a href="#">GELLIBRAND RIVER @ BURRUPA</a>	Active	WES	11-Apr-05	12-Jul-05	<a href="#">4</a>
<a href="#">235234</a>	<a href="#">LOVE CREEK @ GELLIBRAND</a>	Active	WES	12-Apr-05	14-Jul-05	<a href="#">4</a>
<a href="#">235210</a>	<a href="#">LARDNER CREEK @ GELLIBRAND</a>	Active	THIESS	7-Nov-74	14-Jun-05	<a href="#">32</a>
<a href="#">235211</a>	<a href="#">KENNEDYS CREEK @ KENNEDYS CREEK</a>	Active	WES	11-Apr-05	12-Jul-05	<a href="#">4</a>
<a href="#">235236</a>	<a href="#">GELLIBRAND RIVER @ D/S OF DAM SITE G5A</a>	Inactive	THIESS	1-Jan-81	1-Jan-90	<a href="#">10</a>
<a href="#">235228</a>	<a href="#">GELLIBRAND RIVER @ GELLIBRAND</a>	Inactive	THIESS	1-Jan-74	1-Jan-89	<a href="#">16</a>
<a href="#">235208</a>	<a href="#">GELLIBRAND RIVER @ CARLISLE</a>	Inactive	THIESS	1-Jan-73	1-Jan-91	<a href="#">19</a>
<a href="#">235239</a>	<a href="#">TEN MILE CREEK @ KAWARREN</a>	Inactive	THIESS	1-Jan-85	1-Jan-95	<a href="#">11</a>
<a href="#">235240</a>	<a href="#">YAHOO CREEK @ KAWARREN</a>	Inactive	THIESS	1-Jan-85	1-Jan-95	<a href="#">11</a>
<a href="#">235241</a>	<a href="#">PORCUPINE CREEK @ KAWARREN</a>	Inactive	THIESS	1-Jan-86	1-Jan-95	<a href="#">10</a>
<a href="#">235200</a>	<a href="#">CARLISLE RIVER @ CARLISLE RIVER</a>	Inactive	THIESS	2-Mar-30	30-Apr-68	<a href="#">11378</a>
<a href="#">235212</a>	<a href="#">CHAPPLE CREEK @ CHAPPLE VALE</a>	Inactive	THIESS	1-Jan-73	1-Jan-89	<a href="#">17</a>
<a href="#">235213</a>	<a href="#">SKINNER CREEK @ CHAPPLE VALE</a>	Inactive	THIESS	18-Jun-64	8-Jan-71	<a href="#">2029</a>

## Appendix C - Map of the Gellibrand River Catchment

# GELLIBRAND RIVER

## Environmental Flow Sites

### LEGEND

-  Site Location
-  Towns
- Reaches**
-  Reach 1
-  Reach 2-a
-  Reach 2-b
-  Reach 3
-  Reach 4
-  Reach 5
-  Reach 6
-  Freeway
-  Highway
-  Arterial Road
-  Sub-arterial Road
-  Connector Roads
-  Local Roads
-  2WD Track
-  4WD Track
-  Bike Track
-  Walking Track
-  Catchment Boundary

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