Environmental Flow Determination for Painkalac Creek

Issues Paper

Prepared by

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for the

Corangamite Catchment Management Authority

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The Painkalac Creek Environmental Flows Technical Panel

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Abbreviations used in this report

CMA	Catchment Management Authority
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment
EPA	Environment protection Authority
EVC	Ecological Vegetation Class
ha	hectares
ML	Megalitres (1,000,000 litres)
NRE	Department of Natural Resources and Environment

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Cover Photo: Painkalac Creek – photo from Geoff Vietz

Summary

This Issues Paper represents the second output from the Painkalac Creek environmental flow investigation. The first report – the Site Paper – identified preliminary environmental data that had been collected, and confirmed that only a single freshwater reach (from the estuary head to the reservoir) needed to be investigated further.

The Issues Paper presents more detailed environmental information (supplemented with information from the Community Advisory Committee, local residents and from the field inspection), leading to the development of Environmental Flow Objectives for the creek.

Eight Environmental Flow Objectives are proposed for Painkalac Creek:

- *Maintain or improve channel form and processes for ecological benefit.*
- *Restore self-sustaining populations of migratory fish species (Short-finned eels, Common galaxias, Spotted galaxias, Broad-finned galaxias, Pouched lamprey and Tupong) in Painkalac Creek.*
- *Restore self-sustaining populations of non-migratory fish species (Flat-headed gudgeon and Australian smelt) in Painkalac Creek.*
- *Restore macroinvertebrate communities to meet SEPP (Waters of Victoria) environmental quality objectives for Forest-B segments.*
- *Maintain and enhance healthy and diverse communities of native aquatic vegetation in the in-stream and fringing zones.*
- *Maintain and enhance biofilms on submerged surfaces, particularly coarse woody debris; and*
- *Maintain and enhance healthy and diverse communities of native vegetation in the riparian zone.*
- *Entrain terrestrial organic matter from the benches into the stream.*

For each objective, a series of flow functions has been determined – flow-dependent processes that must occur in the creek in order to achieve the objectives. Flow functions include measures such as the provision of adequate habitat, flushing excess silt of habitat surfaces, preventing summer water quality decline, and stimulating fish spawning migrations.

For each of these functions, the types of flows required have been determined. These include the flow component (low flow, high flow, flood flow), time of year, the frequency (if known) and the duration (if known). For each flow type, criteria for assessment have been developed (e.g. depth of water required to allow fish passage for certain species, velocity of water to prevent water quality decline in pools).

Contents

1. Introduction

In 2004, the Surf Coast Shire developed the Painkalac Estuary Management Plan (Surf Coast Shire, undated[1]) to help improve the health and management of the Painkalac Creek estuary. The plan also included actions to maintain and improve the health of Painkalac Creek downstream of the reservoir. During the production of the plan, the Aireys Inlet community raised concerns about the effects of the reservoir on river health.

A key action identified in the plan was to:

> *Undertake an investigation into environmental flow requirements for fresh water and estuarine systems to the Painkalac Creek from the Aireys Inlet Reservoir, with a view to reviewing the Bulk Entitlement held by Barwon Water. The investigation should also consider the potential role of the Aireys Inlet Reservoir in flood management downstream.* (p. 25)

Subsequently, Tim Doeg, Paul Boon and Geoff Vietz were contracted by the Corangamite Catchment Authority to conduct an environmental flow study of the freshwater systems of Painkalac Creek using the FLOWS method – the standardised Statewide Method For Determining Environmental Water Requirements in Victoria (NRE, 2002a[2]).

An initial analysis of available environmental and resource use data for Painkalac Creek, collected for the Site Paper (Doeg *et al*., 2007[3]) suggested that Painkalac Creek can be divided into 4 reaches on the basis of land tenure, hydrology, water resource development and water quality (Table 1.1).

Table 1.1 Reaches identified in the Painkalac Creek catchment

Reach	Location	Rationale
1	Painkalac Creek upstream of Painkalac Reservoir	Forested catchment in National Park; No water resource development; Freshwater reach; Fast-flowing macroinvertebrate taxa; Presumed natural water quality
2	Painkalac Creek from Painkalac Reservoir to the head of estuary (downstream of Distillery Creek confluence)	Private land tenure; Disturbed or altered riparian vegetation; Subjected to water resource use; No major tributary inflows; Freshwater reach; Some slow-flowing macroinvertebrate taxa; Water quality impacts from landuse.
3	Distillery Creek	Major tributary of Painkalac Creek; Forested catchment; Extensive *Melaleuca* swamps Freshwater reach; No water resource development.
4	Estuary reach (downstream of the Distillery Creek confluence to the sea)	Estuary reach

[1] Surf Coast Shire (undated) *Painkalac Estuary Management Plan*. Surf Coast Shire.

[2] NRE (2002a) *FLOWS- a method for determining environmental water requirements in Victoria*. Catchment and Water Division, Department of Natural Resources and Environment, East Melbourne.

[3] Doeg, T.J., Vietz, G. and Boon, P.I. (2007) Painkalac Creek *Environmental Flow Investigation: Site Paper*. Prepared for the Corangamite Catchment Management Authority, Colac

In terms of the required environmental flow study, only Reach 2 needs to be included as Reaches 1 and 3 have no water resource development (and hence natural flows), and the environmental water requirements of the estuary reach (Reach 4) cannot be determined using the current FLOWS method.

The selection of a single reach for further study was confirmed at a meeting of the Steering Committee and Community Advisory Committee held at Aireys Inlet (31 July 2007).

1.1 Project Objectives

The objectives of the project are to:

- Identify water dependent environmental and social values within the reach;
- Gauge the current health of the environmental values;
- Recommend an environmental flow regime that will sustain the identified environmental values; and
- Develop recommendations to address issues that may complement or could reduce the efficacy of the flow recommendations

1.2 The Study Area

Painkalac Creek rises at an elevation of 430 m in the deeply-dissected rolling hills at the north-eastern end of the Otway Ranges, and flows in a generally easterly direction for about 20 km where it enters Bass Strait on the western side of the township of Aireys Inlet (Figure 1.1). The freshwater section of the catchment has a total area of 57.2 km^2, including the main stem of the creek (39.2 km^2) and the Distillery Creek sub-catchment (18.0 km^2) which meets Painkalac Creek about 200 m south west of the Old Coach Road crossing.

Painkalac Creek passes through the reservoir site at 23 m above sea level. Downstream of the dam the channel passes through extensive alluvial valley deposits. In this section, the channel is most commonly partially confined, abutting the channel margin to the north in the upper reaches, before shifting to the steep sided southern margin and following this to the south (Figure 1.1). The channel becomes unconfined for the majority of the estuarine reach.

The annual rainfall average is approximately 650mm. Highest rainfall is in the months between April and November, with the wettest month being August and the driest being January.

The lower part of the Painkalac Creek valley was largely cleared of woody vegetation early in the 19th Century and much of the cleared land was used for grazing stock.

The boundary between the estuary reach and the freshwater reach has not been specifically delineated. GHD (2005[4]) suggests that the tidal influence of the estuary extends "approximately to the junction of Distillery and Painkalac Creek" (p. 4), and spot water quality results (GHD, 2005) show a distinct difference between the salinity at Old Coach Road and further downstream.

[4] GHD (2005) *Painkalac Creek and Estuary Pollution Source Investigation*. Report to Surf Coast Shire.

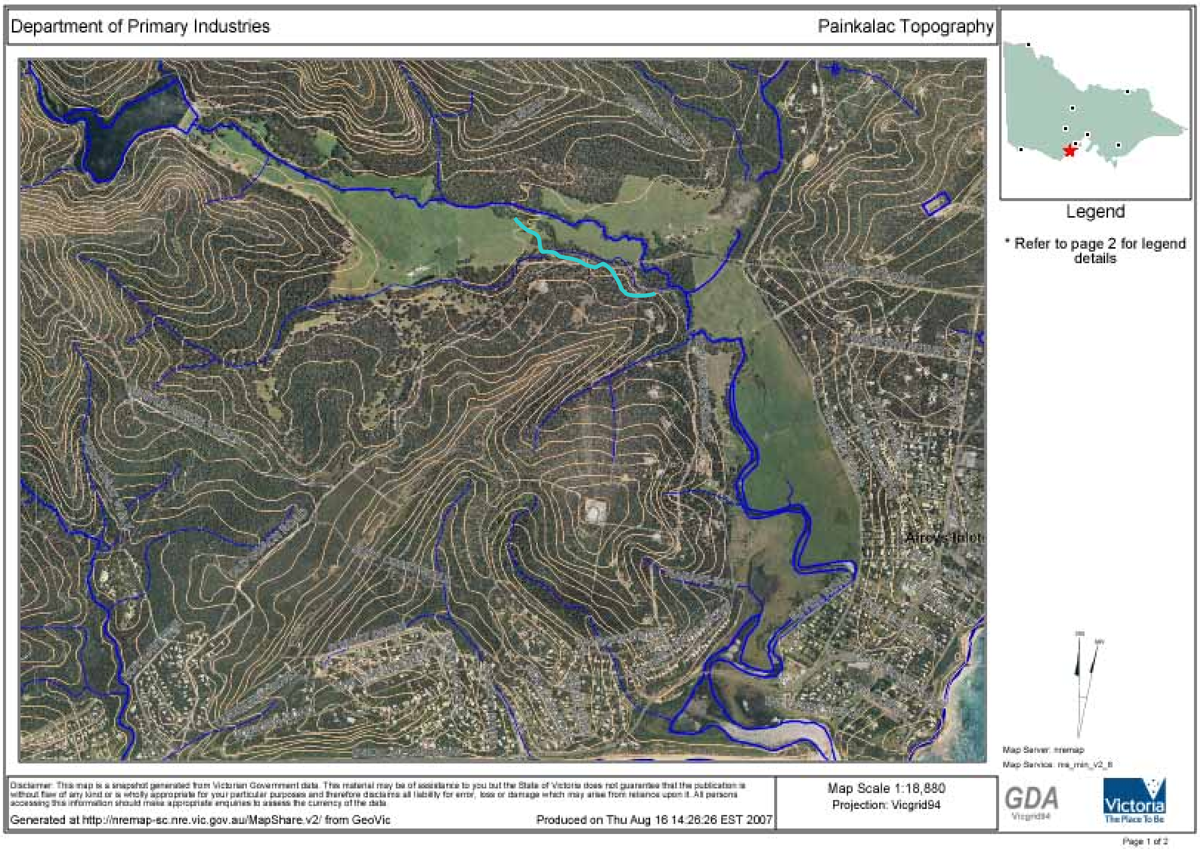

Figure 1.1 Painkalac Creek catchment map (note the light blue line represents the current channel of Painkalac Creek which has been incorrectly positioned in the previous mapping).

1.3 Outline of this report

Following this introductory section, Section 2 provides details of the methods used in the study – the FLOWS method. Section 3 details the main stream processes and the current condition of the Painkalac Creek study reach. This concentrates on information that leads to the development of Environmental Objectives, and Environmental Flow Requirements to achieve those objectives. A synthesis of the Environmental Flow Requirements is presented in Section 4. The final Section 5 discusses other non-flow related catchment issues that may be important if the objectives are to be achieved.

This Issues Paper does not have the role of determining recommendations. The end result of the Issues Paper is primarily a set of Environmental Objectives for key environmental assets for each river, and the Environmental Flow Requirements to achieve those objectives. These are used to guide the development of recommendations. The actual recommendations are developed in the second stage of the project.

2. Description of the FLOWS method

The recommendations for environmental flows in Painkalac Creek will be developed using the standardised Statewide Method For Determining Environmental Water Requirements in Victoria, referred to as the FLOWS method (NRE, 2002a). The major steps in applying the FLOWS method to environmental flow studies are shown in Figure 2.1.

2.1 Flows Method - Stage 1

Environmental flow recommendations are established in two stages. Stage 1 involves the collection of available data on ecology and hydrology of the study area, from published work and unpublished sources, that are required for environmental flow recommendations.

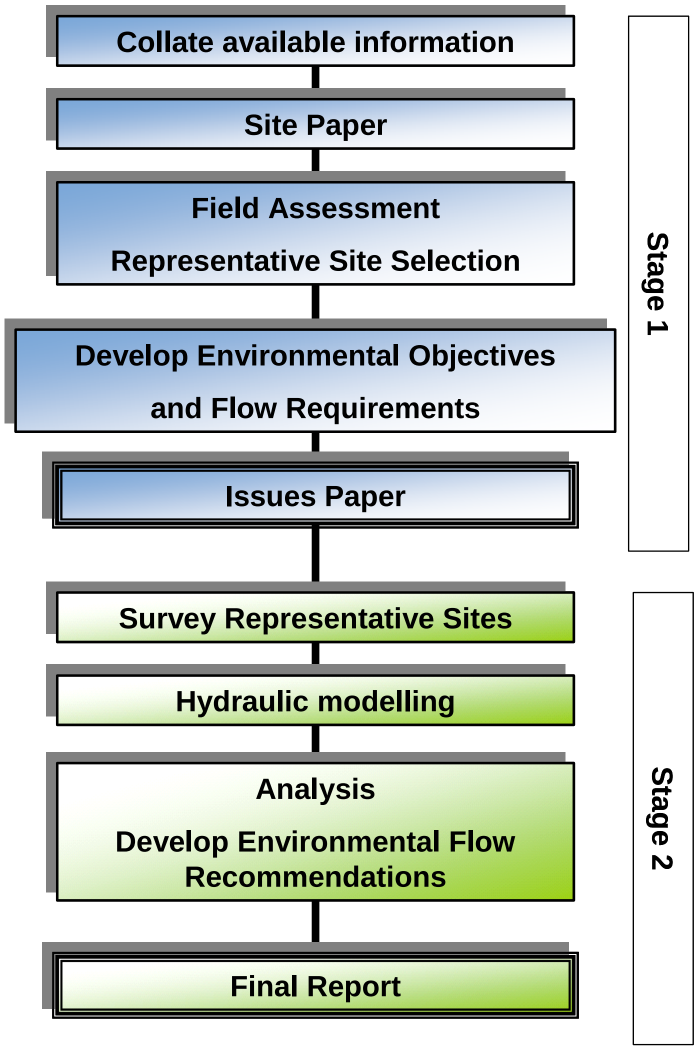

Figure 2.1 Outline of the steps in the FLOWS method. This Issues Paper represents the final output of Stage 1 of the process.

From this information, the catchment is divided into reaches for further study. Natural discontinuities in biodiversity values (primarily fish, macroinvertebrates and vegetation), hydrology (e.g. tributary inflows, water resource structures), geology and geomorphology are identified and examined to determine areas of the catchments with similar environmental attributes. The suggested reach delineation is presented in a **Site Paper**. The site paper has been prepared (Doeg *et al*., 2007), suggesting that only a single reach needs to be selected in Painkalac Creek for further study.

A field inspection of reach is conducted by the Technical Panel within each reach. One or more “Representative Sites” are selected for further study in each reach. Representative Sites are those determined to have features present (e.g. pool-riffle sequences, in channel benches, levees, inflows to anabranches) that need to be assessed to determine environmental flow recommendations for the entire reach.

The particular features of the Representative Sites are marked by pegs for later survey in Stage 2.

From the environmental information, Environmental Objectives are established for each of the major flow-dependent environmental assets in the reach (in this case: geomorphology, fish, aquatic macroinvertebrates, in-stream and riparian vegetation).

The objectives may be to return an asset back to its natural condition, to a state pre-determined according to various requirements (e.g. State Environment Protection Policies, the objectives of regional management plans), or to a state that represents the best possible environmental condition given prevailing management limitations.

For each of these objectives, the types of flows required to achieve the objective are determined. These include the flow component (see page 6), time of year, the frequency (if known) and the duration (if known). For each flow type, criteria for assessment are developed (e.g. depth of water required to allow fish passage for certain species, velocity of water to prevent water quality decline in pools).

A broad description of the flow regime that would achieve all the objectives for environmental assets can then be determined.

The description of the field inspection, the representative sites, and the Environmental Flow Objectives are detailed in the **Issues Paper**, which completes the output of the first stage of the FLOWS study.

The objectives set for each asset, and the issues identified, are confirmed by the Steering Group and Community Advisory Committee as being suitable for each reach before the project continues.

2.2 Flows Method - Stage 2

In the second stage of the project, the Representative Site is studied in more detail, with cross-sections surveyed across the creek. Cross section include particular features identified in the field inspection which have environmental significance (e.g. pools, riffles, in-channel benches).

A computer-based hydraulic model of each Representative Site is then constructed, which related the channel structure and features to different flows in the creek.

The key output from the hydraulic modelling is a graphic presentation of each cross-section (Figure 2.2). In these, the black line (“Ground” in the legend) represents the ground surface, reflecting the channel shape at the cross-section. Small black squares on the ground line show the exact points where survey measurements were taken (note that these are more frequent within the channel than further out).

Horizontal blue lines within the cross-section represent the water surface at the various flows (which are detailed in the legend).

The outputs used from the model included the flows (ultimately expressed in ML/d) required to cover specified parts of the stream bed to a certain depth, or inundate identified channel units such as benches, or to provide for fish passage.

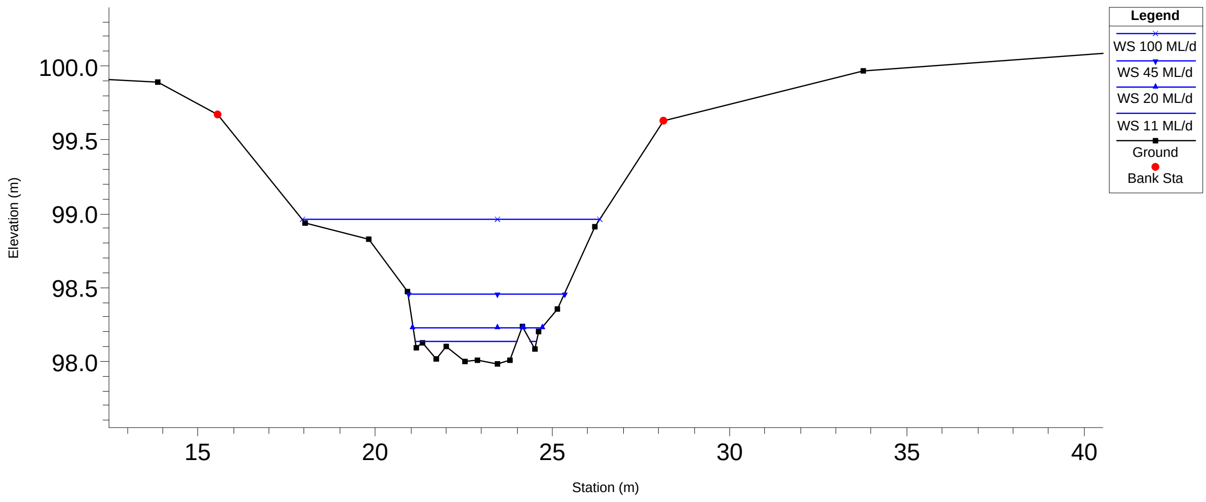

Figure 2.2. Typical output from a hydraulic model showing cross-section of creek and depth of water at different flow rates.

Based on the flow types and criteria identified in the Issues Paper, reach specific environmental flow recommendations are then developed and presented in a **Final Recommendations** report.

2.3 Description of flow types and components used in FLOWS

The FLOWS method requires recommendations to be made for a number of different flow components. Each of these have identified environmental "functions" and can be influenced by the diversion of water. The exact environmental flow recommendations can only be evaluated once data collected in Stage 2 of the project are analysed, but some general comments on each of the flow components can be made here.

- **Zero Flows** (also called "cease-to-flows") – Defined as periods where no flows are recorded in the channel. During these periods, the river may contract to a series of pools that act as a refuge for in-stream biota. There are plants and animals specifically adapted to zero flows, and zero flows may also assist in preventing the spread of some exotic species. Zero flows may, or may not, occur naturally during the drier summer/autumn months.
- **Low "Summer"[5] Flows** – In the FLOWS method, low flows are defined as "the low minimum flow that provides a continuous flow through the channel. The flow may be limited to a narrow area of the channel in the high points of the stream, but will provide flow connectivity between habitats within the channel" (NRE, 2002a, p. 22). This refers to the natural baseflow during the dry season that maintains water flowing through the channel, keeping in-stream habitats wet and pools full.
- **Low Flow Freshes** – A "Low Flow Fresh" refers to a small and short duration increase in flow that lasts for one to several days as a result of localised rainfall during the low flow period. These

[5] The terms "summer" and "winter" in the context of environmental flow studies do not refer to the standard season (December to February, and June to August), but rather to a "low flow season" and a "high flow season" that will be determined from the natural rainfall and flow patterns in the creek.

are important to refresh water quality in pools after periods of low or zero flow flows, flushing sediment deposited during low flows, or to allow temporary movement of animals through the reach.

- **Low "Winter" Flows** – this component refers to the persistent increase in baseflow that occurs with the onset of the wet season. These are flows that cover the bed and maybe some low in-channel benches or bars. This allows full connection between all habitats in the river, important for fish passage during migration.
- **High Flow Freshes** – "High Flow Freshes" refer to long sustained increases in flow during the high flow period as a result of heavy rainfall events, extending over several weeks. High flow freshes can inundate benches in the channel, may act as triggers for fish migration/breeding, and create important scour disturbance in the channel.
- **Bankfull Flows** – These flows fill the channel, but do not spill onto the floodplain. They have mainly geomorphological functions, maintaining the channel shape and form (e.g. preventing in-filling of pools or channel contraction).
- **Overbank Flows** – Overbank flows are higher than the bankfull flows, and spill out of the channel onto the floodplain. These are ecologically important for wetlands, and for bringing food (either carbon dissolved from the floodplain floor, or in the form of leaves and twigs) from the floodplain to the stream channel.

These different components can be visualised by the depth of water they produce in a channel cross-section (Figure 2.3). Each has different ecological functions in a river, and characteristics that need to be identified in any environmental flow study.

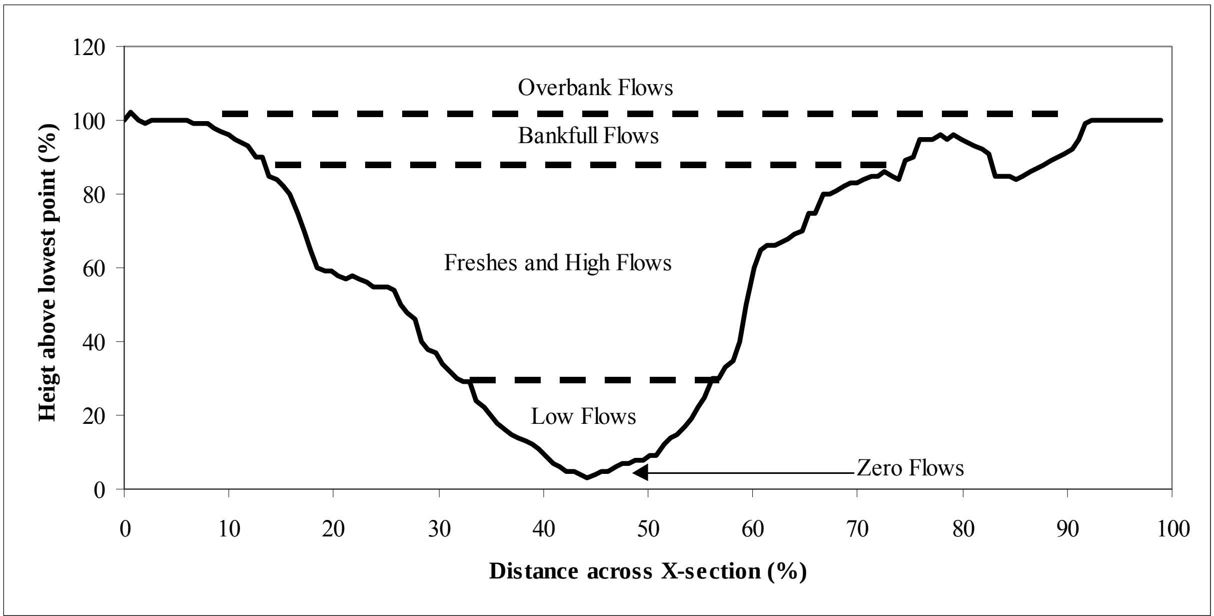

Figure 2.3 Hypothetical cross-section of a stream channel showing where each flow component is located

3. Environmental Objectives and Flow Requirements

3.1 The Representative Reach

Following a field inspection of the reach on 31 July 2007, a representative site was selected just upstream of the bridge on the Old Coach Road.

The site consisted of a series of pools (some over 1.5 m deep) separated by either short drop cascades formed by fallen timber (Figure 3.1) or by long narrow and shallower run sections (Figure 3.2). Woody debris in the pools and in-channel benches where organic litter accumulated are relatively common.

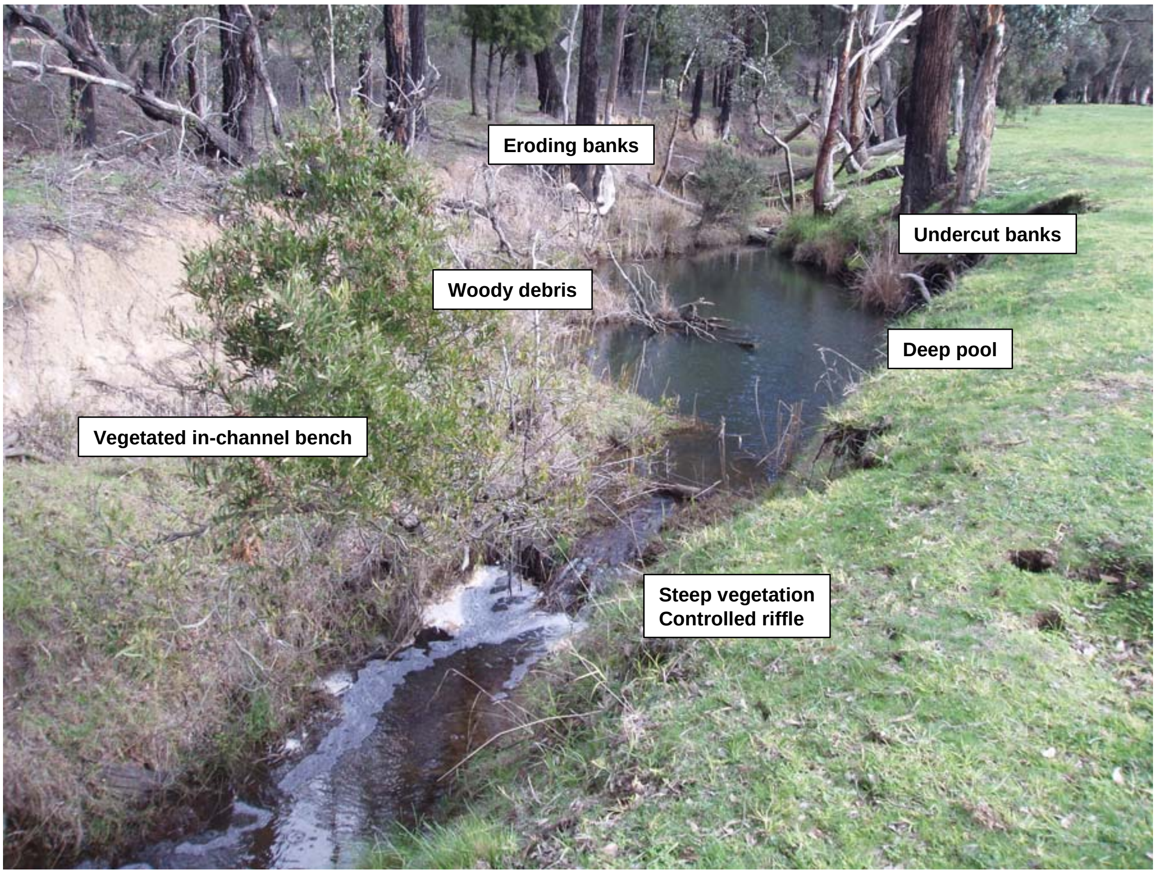

Figure 3.1 Site photo showing deep pool and major channel features.

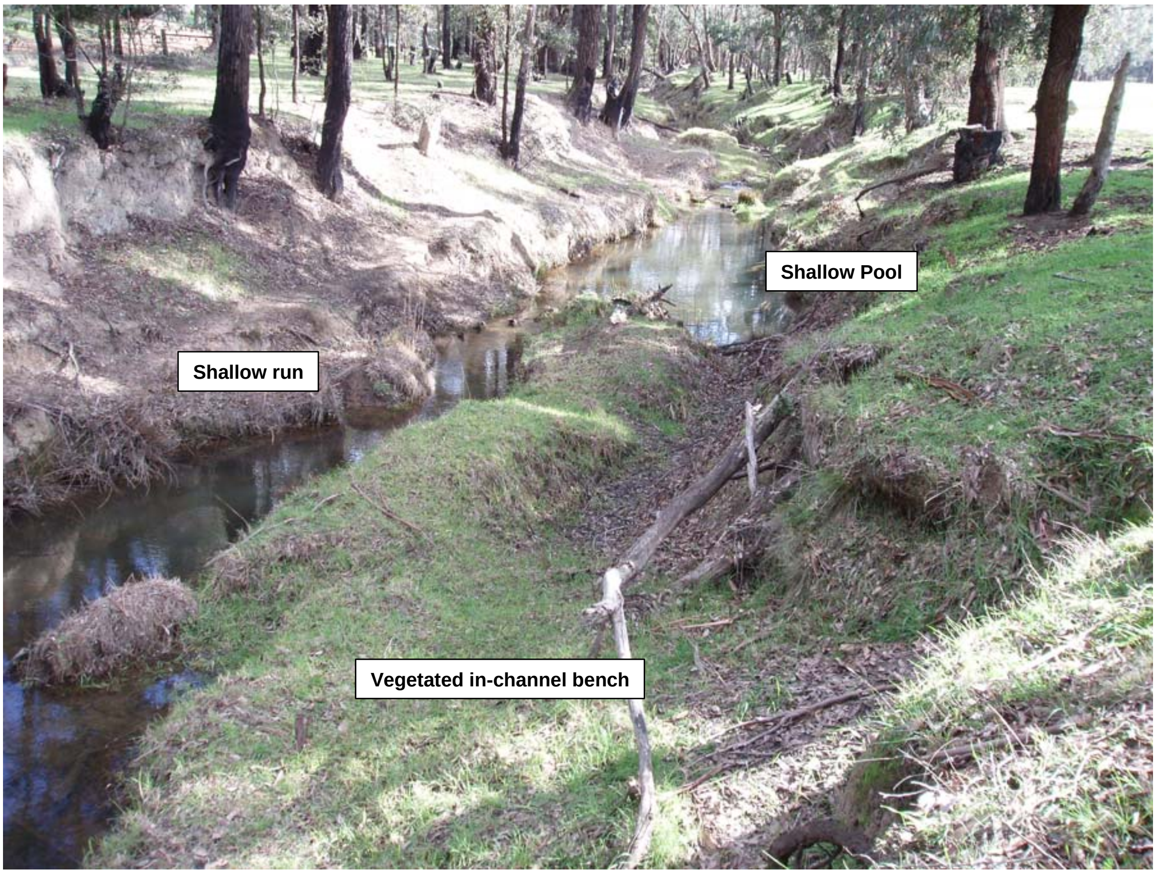

Figure 3.2 Site photo showing shallower pool, shallow run and in-channel bench.

3.2 Geomorphology

Fluvial geomorphology is the science dealing with the changes in the geological form and structure of a waterway. Geology and soil type have a considerable impact on the physical form and ecological functioning of the channel, as does vegetation structure and land use. Channel shape and adjustment are strongly influenced by hydrologic characteristics including flow magnitude, frequency and duration. Timing of flows may also be important where variation occurs in the protective vegetation cover due to seasonality or recovery from a previous flow event.

The geomorphic characteristics and condition are addressed for the Painkalac Catchment based on the available literature and the field inspection conducted by the team on the 31st July 2007. The information is more reliant on the latter as the geomorphic information on the catchment was scant. The fluvial geomorphology assessment has two aims:

- to describe the geomorphic setting for the channel and floodplain; and
- to identify important geomorphic units and the desired channel structure.

3.2.1 Catchment Physiography

The geological structure of Painkalac Creek formed between 50 and 150 million years ago with uplift of the Cretaceous rocks of the Otway Ranges. The result is cliffed coastal margins which in the last 6,000 years have formed sandy beaches, dunes and sand barriers (Surf Coast Shire, undated). The geology of the catchment consists of Lower Cretaceous felspathic sandstone and mudstone parent material with tertiary era sedimentation. The two main formations within the catchment are the Eastern View Formation comprising unconsolidated silts, clays, sands and gravels and the Demons Bluff formation comprising volcanics with clays and sand, as well as quartz and gravel beds. A well defined intersect appears between these formations and can be seen by the more resistant material of the Demons Bluff Formation, from the southwest to northeast.

The weathered material forms sands, silts and clays with some gravels, the finer materials being more common (Forsyth and Ransome, 1978[6]). The soils of the Painkalac valley tend to have low permeability and commonly comprise loam or clay loam up to sandy loam, often overlying surface texture grading to a clay/silty clay subsoil (Forsyth, 1980[7]).

3.2.2 Catchment Geomorphology

Painkalac Creek has a history of instability and channel change, with an avulsion forming the present channel. The current channel, identified in Figure 1.1 in light blue, flows to the south and appears to have captured an unnamed tributary to the south. The old channel rejoins the existing channel downstream of Old Coach Road. Anecdotal evidence suggests the avulsion occurred 60 years ago (Graeme McKenzie, Landholder, pers. comm.). The flow split between the existing stem channel and the old channel is not certain but field inspection suggests the former channel only flows at higher stages nearing bankfull. The old channel is of much lower capacity and roughness than the stem channel.

Painkalac Creek is actively incising (Earth Tech, 2005a[8]). To address the erosion issues in Painkalac Creek the Corangamite CMA engaged Earth Tech to assess the potential for installing rock chute structures. One structure (Figure 3.3) was installed in the stem channel downstream of Old Coach road in October 2005 (Mark Turner, Corangamite CMA, pers. comm.). The aim of this weir is to maintain bed stability. The rock chute installed comprises a 1m drop from a crest elevation of 4.2 mAHD. Hydraulic modelling of the rock chute found that it impacted on the 100 year event causing inundation of the bridge (Earth Tech, 2005b[9]). It is evident that little widening of the channel downstream of the bridge has been undertaken.

On private land in the alluvial section, an active head cut on the floodplain is present, and said to be the result of flows overtopping the banks of Painkalac Creek (Earth Tech, 2005b). Earth Tech recommendations for this head cut included rock protection and riparian fencing, but this has not been done.

3.2.3 Geomorphic Condition and Threats

In the representative reach, upstream of Old Coach Road, the channel is of low sinuosity (close to unity) and high slope (≈ 0.01 m/m). The channel comprises sandy-silt substrate with high levels of organic matter. Banks are also sandy silt, with some clays evident. Channel diversity is high with numerous horizontal surfaces within the channel, also referred to as benches. These surfaces are most likely the result of bank slumps. The bank slumps provide a nucleus upon which further deposition is encouraged. These surfaces are commonly vegetated and can be considered a permanent feature of the

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[6] Forsyth, D.A. and Ransome, S.W. (1978) *Painkalac Creek (Aireys Inlet) Catchment. A proposal for proclamation prepared for consideration by the Land Conservation Council*. Soil Conservation Authority, Kew, Victoria

[7] Forsyth, D.A. (1980) *Report on a land use determination for the Painkalac Creek water supply catchment.* Report to Soil Conservation Authority, Kew

[8] Earth Tech (2005a) Letter to Mark Turner from Lisa Roach RE: summary of investigations. Febuary 2006.

[9] Earth Tech (2005b) Letter to Mark Turner from Paul Sureda RE: chute design. July 2005

channel, as stream powers required to remove these features once vegetated are extremely high. Bank erosion is evident but is most likely not active at present. Erosion can in part be attributed to the low density of native vegetation providing structure and reducing erosion by desiccation (drying and cracking). Undercut banks are common, and below storages this can often be attributed to controlled releases from storages.

Figure 3.3 Rock chute installed downstream of Old Coach Road bridge

Bed diversity in the channel is good, with high variability in depth. Much of the variability can be attributed to root mats acting as riffles and confining flow. In addition, the large woody debris loading is high, and at several sites debris jams act as hydraulic controls increasing pool depth.

The geomorphic impact of the storage on Painkalac Creek would be expected to be a reduction in channel forming flows (half channel full to bankfull) with greater incision in the lower portions of the channel during constant releases (summer period). The reduction in the very low flows (95^{th} percentile and less) could also encourage vegetation to colonise the bed of the channel, which can lead to greater bank erosion during flowing periods.

The storage would also reduce sediment supply to Painkalac Creek from upstream, particularly bed load sediment. If the supply of bed load sediment to the lower channel is significantly reduced the channel will preferentially incise (erode its bed) and further expansion of the channel can occur. However, the lower reaches of Painkalac Creek would be expected to be supplied with sediment from the McKenzies Creek catchment. The McKenzies Creek catchment is relatively steep and the upper tributaries have been realigned to flow beneath the dam access road, making an efficient path for sediment supply.

The geomorphic condition of the channel is difficult to assess due to the lack of information on pre-European form, and the recent nature of channel change. The lack of riparian vegetation combined with high flow events are probably the main causes of instability in the channel. In the reach downstream of Old Coach Road the channel comprises much higher densities of native vegetation and the channel displays a higher sinuosity. This suggests that the representative site may eventually migrate to increase its sinuosity, which will also increase the channel slope and reduce bed incision (which can lead to bank collapse). In general the geomorphic condition of the channel is good, with high densities of woody habitat to increase roughness and provide refuge, reasonable levels of overstorey riparian vegetation, no evidence of continuing major instability and good connectivity with the floodplain.

3.2.4 Environmental objectives for geomorphology

The geomorphic objectives for this study are to:

- *Maintain or improve channel form and processes for ecological benefit.*

As identified by the Victorian River Health Strategy (NRE, 2002b[10]), '*Managing the River Channel',* this objective includes maintaining:

- substrate type and diversity;
- the presence of pools and riffles;
- channel shape including the presence of backwaters and undercut banks;
- the presence of woody debris and riparian vegetation; and
- connectivity - the degree to which there is access for biota, organic material and sediments to move both along the river and laterally into floodplains and wetlands.

3.2.5 Flow Requirements for Geomorphic Objectives

It is important to note the aim of the geomorphic objectives is to provide habitat and conditions required to meet ecological and process objectives.

Table 3.1 details the flow requirements to achieve various geomorphic processes, designed to maintain natural habitat features and linkages between the river and the floodplain.

The geomorphic condition and stability is significantly affected by riparian vegetation condition. For example, low flows are important for the maintenance of plants which assist in stabilising the toe of the river bank, and may also prevent terrestrial plants from establishing within the channel, which may encourage erosion during a higher flow. Thus, geomorphic objectives also rely on riparian vegetation objectives.

[10] NRE. (2002) *Victorian River Health Strategy - Healthy Rivers, Health Communities and Regional Growth.* Department of Natural Resources and Environment, Melbourne

Table 3.1 Summary of flow requirements to achieve geomorphology objectives in Painkalac Creek

Objective	Flow Process/Function	Flow Components	Timing	Criteria
Maintain or improve channel form and processes for ecological benefit	Maintain quantity and quality of habitat in pools by preventing siltation.	Low Flow Freshes High Flow Freshes	All year	Positive average velocity in pools Mean channel scour in pools >1.4 Nm^{-2}
	Movement of bed material to maintain bed diversity for water depth variation.	High Flow Freshes	Winter-Spring	Mean channel scour in runs >15 Nm^{-2}
	Control riparian vegetation encroachment to prevent catastrophic erosion processes	High Flow Freshes Bankfull	Anytime	See vegetation section
	Maintain channel form and key habitats, including in-channel benches.	Bankfull	All year	Mean channel scour in pools >15 Nm^{-2}
	Maintain channels and inlets for connectivity of main channel with important floodplain and the old channel zones	Overbank	Anytime	Determined from physical transects

3.3 Fish

According to the Painkalac Estuary Management Plan (Surf Coast Shire, undated), a survey in 2001 collected 6 species of native freshwater fish from the Painkalac Creek catchment (excluding estuarine species): Short-finned Eel, Tupong, Small-mouthed Hardyhead, Flat-headed Gudgeon, Common Galaxias and Australian Smelt. A number of other species that are primarily estuarine, but may be found in the lower parts of freshwater reaches included Sea mullet, Yellow-eyed mullet, Tamar River goby and Black bream (G. Peters, Corangamite CMA, unpublished data).

Despite extensive searching, no formal description or documentation on the 2001 survey has been found.

An extensive survey of Otway coast streams in the late 1980's (Koehn and O'Connor, 1990a[11]) found only 4 species in Painkalac Creek: Pouched Lamprey, Short-finned Eel, Common Galaxias and Spotted Galaxias. In streams along the coast from Anglesea to Wye River, these four species were consistently found. In nearby Grassy Creek, four additional freshwater species were recorded: Broad-finned galaxias, Australian grayling, Tupong and Flat-headed gudgeon.

The Estuary Management Plan claims that Mountain galaxias has been recorded in the creek, although no documented record of this species has been located. Koehn and O'Connor (1990a) state that Mountain galaxias is missing from all of the coastal Otway streams from Anglesea to Apollo Bay.

[11] Koehn, J.D. and O'Connor, W.G. (1990a) Distribution of freshwater fish in the Otway region, South-western Victoria. *Proceedings of the Royal Society of Victoria* **102(1)**: 29-39.

A DPI recreational fishing website states that Painkalac Creek "contains Short-finned eel, Pouched lamprey, Flat-headed gudgeon, Common galaxias, Broad-finned galaxias, and Spotted galaxias"[12].

The lack of recent documentation makes a final list of species to be included in the flow study difficult. Eight freshwater fish species are therefore considered to potentially inhabit Painkalac Creek (Table 3.2), and Environmental Objectives for these species will be used to develop environmental flow recommendations.

Table 3.2. Freshwater native fish species found in, and potentially found in Painkalac Creek (✓ - migratory species requiring movement to the sea or estuary)

Common name	Scientific name	Comment	M
Short-finned Eel	*Anguilla australis*	Found in creek	✓
Common Galaxias	*Galaxias maculatus*	Found in creek	✓
Spotted Galaxias	*Galaxias truttaceus*	Found in creek	✓
Broad-finned galaxias	*Galaxias brevipennis*	Found in nearby Grassy Creek	✓
Pouched Lamprey	*Geotria australis*	Found in creek	✓
Tupong	*Pseudaphritis urvilli*	Found in nearby Grassy Creek	✓
Flat-headed gudgeon	*Phylipnodon grandiceps*	Found in nearby Grassy Creek	
Australian smelt	*Retopinna semoni*	Likely to be present	

None of the species on the list (Table 3.2) has a significant conservation status in Victoria (DSE, 2003[13]).

While Australian grayling *Prototroctes maraena* is found in nearby streams, it has not been recorded in Painkalac Creek. While grayling is a species with high conservation significance, it is unlikely that the short length of the freshwater reach in Painkalac Creek is large enough to support a sustainable population. Therefore, no environmental objectives for Australian grayling will be developed.

In addition, River blackfish *Gadopsis marmoratus* once inhabited the Creek (Graeme McKenzie, Landholder, pers. comm.). These are likely to have disappeared from the system due to periods of extreme low or no flow. Koehn and O'Connor (1990a) state that blackfish are missing from all of the coastal Otway streams from Anglesea to Apollo Bay. While the deep pool habitat in the creek is suitable for blackfish (Figure 3.1), there is no opportunity for the species to recolonise the reach, so no environmental objectives for River blackfish will be developed.

The condition of the fish populations – in terms of population size and sustainability – is not known due to the relatively low sampling effort over time. However, the recent extremely dry period, where parts of the creek dried up completely would suggest that populations would have declined significantly, and have been potentially eliminated from substantial proportions of the reach.

3.3.1 Environmental objectives for fish

As it is likely that the populations of fish in the creek have been severely depleted in the past, the Environmental Objectives in Painkalac Creek for fish communities are restore previous populations, in particular, to:

[12] www.dpi.gov.au/angling/35-Otway/ Basin%20TEMPLATE%20Waters.htm#Painkalac (accessed 9/7/07)

[13] DSE (2003) Advisory list of threatened vertebrate fauna in Victoria. Department of Sustainability and Environment, Melbourne.

- *Restore self-sustaining populations of migratory fish species (Short-finned eels, Common galaxias, Spotted galaxias, Broad-finned galaxias, Pouched lamprey and Tupong) in Painkalac Creek.*

- *Restore self-sustaining populations of non-migratory fish species (Flat-headed gudgeon and Australian smelt) in Painkalac Creek.*

Despite recent disturbances due to low flows, these objectives should be seen as achievable. Some individuals of non-migratory species may have survived in deeper pools located downstream of the reach (near the horse farm). Other migratory species will be able to recolonise the reach from downstream and from the sea (for species with marine phases).

3.3.2 Flow requirements for native fish community objectives

The water requirements for fish species in Painkalac Creek can be broken down into a number of different components. Flows are required that provide for: habitat availability, habitat quality, localised movement, migration triggers and movement, and spawning triggers.

Habitat availability (all species)
A major water requirement of the fish species in Painkalac Creek is to ensure that adequate habitat is available through the year to maintain populations. This is particularly important during low flow periods, when the creek can dry to a series of isolated pools, with little or no flow between them. During these periods, fish will only be found in these pools. Maintaining the amount of habitat in these refuge pools is therefore essential for the sustainable survival of all fish species.

Habitat quality (all species)
During periods of low flow, there can be an increase in water temperatures and a decline in dissolved oxygen within the pools. Flows must therefore be provided that prevent water quality decline to the point where it threatens the fish species present. This can be achieved by determining a level of continuous flow that prevents water quality decline or sedimentation, or the provision of freshes that regularly refresh water quality.

In addition, some of the species present lay eggs either on the riverbed substrate or on vegetation. Regular flushes of water are required in the lead up to the breeding season to prevent excessive sedimentation of spawning substrates.

Localised Movement (all species)
Under low flow conditions, the fish present in some pools may die out. To allow for the redistribution of populations both during and after low flow periods, short rises in water level are considered necessary to allow movement of individuals along short distances in the reach, thus mixing the populations and allowing fish to recolonise vacant habitat.

Localised movement is not required continuously over summer, so freshes would be adequate to allow movement between refuge habitats.

Localised movement is also desirable in the lead up to the breeding season for the two non-migratory species (Smelt and Flat-headed gudgeon), and migratory species that spawn in freshwater reach (Spotted galaxias and Broad-finned galaxias). The main spawning periods are spring for the non-migratory species, and autumn to winter for the migratory species.

Migration and Spawning (migratory species)
The six migratory fish in Painkalac Creek exhibit three different types of migration (Table 3.3). Common galaxias, Tupong and Short-finned eels adults live in freshwater and migrate downstream to the estuary or sea to spawn. Pouched lamprey adults live in the sea and migrate upstream into

freshwater to spawn. Spotted galaxias and Broad-finned galaxias adults live and spawn in freshwater and the larvae are washed downstream to the sea.

Many migratory species require rises in flows during the breeding season to initiate migration. Flows that provide a migration trigger are required for Tupong (Koehn and O'Connor, 1990b[14]), and also to provide adequate depths over shallow areas of the stream to allow migration during the autumn spawning/migration period for Common galaxias and Tupong.

Table 3.3 Spawning and migration patterns of freshwater fish in Painkalac Creek

Common name	Migration and spawning	Timing
Short-finned Eel	• Adults migrate to sea (spawning off the north Australian coast)	• Spring-summer
	• Larvae/juveniles migrate upstream	• Spring-summer
Common Galaxias	• Adults migrate to estuary, larvae washed to sea	• Autumn
	• Juveniles migrate upstream	• Spring
Spotted Galaxias	• Spawns in freshwater reach, eggs laid among aquatic vegetation. larvae swept downstream to sea	• Autumn to winter
	• Juveniles migrate upstream	• Spring
Broad-finned galaxias	• Spawns in freshwater reach, eggs laid outside of creek in high flow and hatch on subsequent high flow, larvae swept downstream to sea	• Autumn to winter
	• Juveniles migrate upstream	• Spring
Pouched Lamprey	• Adults migrate upstream from sea in to spawn, larvae swept downstream to sea	• Spring-summer
Tupong	• Moves to estuary to spawn, triggered by increased flows, adults may return upstream[15]	• Autumn to winter
	• Juveniles migrate upstream	• Spring

Spotted galaxias and Broad-finned galaxias do not to migrate as adults prior to spawning, but similar increases in flow are required for these species to act as spawning cues and to allow for the washing of larvae from freshwater to the sea. Broad-finned galaxias require two such flow increases – one to lay eggs along the margin of the creek, and another to stimulate hatching and washing larvae to sea (O'Connor and Koehn, 1998[16]). Between the flows, eggs are out of the water, in damp areas. Hatching only occurs when eggs are inundated by a subsequent flood.

Pouched lampreys migrate upstream to spawn during spring and summer. Therefore, adequate periods of higher flows are required to allow movement during this period**.**

No specific flows are required for Short-finned eel movement, as they have the ability to traverse across very shallow water (or even damp land) for some distance.

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[14] Koehn, J. D. and O'Connor, W. G. (1990b) *Biological Information for Management of Native Freshwater Fish in Victoria.* Government Printer, Melbourne

[15] MDBC fact sheet (accessed 7/8/07)

[16] O'Connor, W. G. and Koehn, J. D. (1998) Spawning of the broad-finned galaxias *Galaxias brevipennis* Gunther (Pisces: Galaxiidae) in coastal streams of southeastern Australia. *Ecology of Freshwater Fishes* **7**: 95-100

Spawning (non-migratory species)

The two non-migratory species – Australian smelt and Flat-headed gudgeon – spawn in spring to early summer. Spawning for smelt is triggered by increasing water temperatures, and the trigger for Flat-headed gudgeon is unknown. Eggs of Australian smelt are demersal, sinking to the bottom and attaching to debris, vegetation or the bottom substrate[17]. Flat-headed gudgeon eggs are attached directly to hard surfaces[18]. Higher flows that scour any surface sediment from egg-laying sites are required prior to the breeding season.

The flow requirements to achieve the native fish objectives are summarised in Table 3.4. Included in the table are a number of criteria which will be used to determine magnitude, timing, frequency and duration of flows.

Table 3.4 Summary of flow requirements to achieve native fish objectives in Painkalac Creek

Objective	Flow Process/Function	Flow Components	Timing	Criteria
Restore self-sustaining populations of migratory and non-migratory fish species	Maintain habitat in pools for all species	Low Summer Flow Low Winter Flow	All year	Median pool depth > 0.2 m[19]. Lower parts of edge vegetation permanently inundated
	Provide occasional adequate depth in runs between pools for movement of all species	Low Flow Freshes	Summer/Autumn	Median depth of runs > 0.1 to 0.2 m[20]
	Flush sediments from aquatic vegetation in lead up to spawning season	Low Flow Freshes High Flow Freshes	Jan-Apr Aug-Nov	Mean channel scour in pools and runs >1.4 Nm^{-2}
	Change in flow to stimulate migration of Tupong and Common galaxias	Freshes around the Transitional Low-High Flow Season	March-June	No criteria available. Determined from other factors (e.g. water quality criteria below)
	Change in flow to stimulate spawning of Spotted and Broad-finned galaxias	Freshes around the Transitional Low-High Flow Season	March-June	Flows that allow Broad-finned galaxias access to channel edges
	Wash fish larvae downstream	Low Winter Flow	May-July	No criteria available. Determined from other factors
	Allow regional scale movement between freshwater and estuary for migratory species (upstream and downstream)	Low Winter Flow	April - November	Median depth of runs > 0.1 to 0.2 m
	Prevent water quality decline	Low Flow Freshes	Summer-Autumn	Positive average velocity in pools

[17] Native Fish Australia Fact Sheet www.nativefish.asn.au/smelt.html accessed 5/12/07

[18] Native Fish Australia Fact Sheet www.nativefish.asn.au/fhgudgeon.html accessed 5/12/07

[19] Depth criterion based on data from Tasmania on depth preferences of small galaxiid species - Howland, M., Davies, P., Bluhdorn, D. and Andrews, D. (2001) *Gordon River Fish Assessment*. Appendix 8: Basslink Integrated Impact Assessment Statement. Hydro Tasmania, Hobart.

[20] Many environmental flow studies in southern Victoria use 0.12 m as the minimum depth for small fish passage.

3.4 Other water dependent vertebrates

While Platypus and Swamp Antechinus have been reported from the creek in the past (Graeme McKenzie, landholder, pers. comm.), the current status of populations is unknown, although there appear to have been no recent sightings.

Many vertebrates have been associated with the wetlands and the estuary section, including many reptile, amphibian and bird species. As the estuary is not part of the environmental flow study, no specific environmental objectives are set for the estuarine reach flora and fauna. However, it is important to realise that flows in the creek contribute to the health of the estuary and the flora and fauna it supports.

3.5 Aquatic macroinvertebrates

There are few recent macroinvertebrate data recorded for the freshwater reach of Painkalac Creek.

A single site was sampled by the EPA in April and October 1997 as part of the Monitoring River Health Initiative[21]. While the location of the site was given as "at Aireys Inlet", the grid co-ordinates of the site (38º26.9'S 144º05'E) suggests it to be between the Old Coach Road and the reservoir. Twenty-two families of freshwater invertebrates were collected (EPA, unpublished data). The fauna contained families typically found in flowing streams (mayflies and stoneflies), but also contained taxa more typically associated with slow flowing areas (some beetles and dragonflies).

In October 2006, a further sample was collected by the EPA in the upper Painkalac Creek at the Iron Bark Spur Track crossing. While a similar fauna was found, some of the taxa typical of slow flowing areas were not recorded.

Whether this is a result simply of the different locations of the creek, or reflects the impact of lower flows downstream of the reservoir cannot be established.

Apart from these data, no information on aquatic macroinvertebrates has been found.

3.5.1 Environmental objectives for macroinvertebrates

The State Environment Protection Policy (SEPP) for Waters of Victoria clearly defines objectives for macroinvertebrate fauna throughout the State. In the SEPP, the state is divided into five areas, termed segments (Highlands, two Forest segments, Cleared Hills and Coastal Plains, and Murray and Western Plains). Each segment has different macroinvertebrate objectives, depending on the type of fauna present, and an expected level of disturbance in streams in each segment.

Painkalac Creek lies in the Forests-B segment. The objectives set in the SEPP for macroinvertebrate communities (Table 3.5) in rural areas recognise that some disturbance from land clearing and use has occurred, so the objectives describe the minimum requirements for a community to be in as "healthy as reasonably expected" state. Objectives are set for both riffle samples (collected from fast flowing rocky areas) and edge samples (collected from the edge of the stream). No true riffles are found in Painkalac Creek, so the objectives for edge samples are used.

[21] Metzeling, L. (2001) Australia Wide Assessment of River Health: Victoria Bioassessment Report. Monitoring River Heath Initiative Technical Report no 4, Commonwealth of Australia and VIC Environment Protection Authority

Table 3.5 Edge sample SEPP ecological objectives (Waters of Victoria) for macroinvertebrate communities (non-urban parts of Forests-B Segment).

Measure	Edge Objective
Minimum number of families[22]	23
SIGNAL Score[23]	5.8
AUSRIVAS Score (Band)[24]	0.87 (A)
EPT Index[25]	9
Number of key families[26]	26

As it is likely that some disturbance of the macroinvertebrate communities have occurred in the recent past, the Environmental Objective for aquatic macroinvertebrates is to:

- *Restore macroinvertebrate communities to meet SEPP (Waters of Victoria) environmental quality objectives for Forest-B segments.*

3.5.2 Flow requirements for macroinvertebrate community objectives

Restoring the macroinvertebrate community to meet SEPP objectives requires the maintenance of a suitable low flow in the reach at all times. The baseflow should be sufficient to inundate the major habitats for macroinvertebrate production – in-stream vegetation, woody debris and semi-aquatic vegetation along the edge of the stream – in both the pools and the long shallow runs.

Additional to adequate low flows, short periods of higher flows (low flow freshes) are required to prevent any decline in water quality at low flow over the warmer months.

Higher scouring flows within the channel are required to prevent the build up and dominance of filamentous algae on habitat surfaces. The natural biofilms (composed of algae, fungi and bacteria) on these surfaces provide a valuable food source for some macroinvertebrates, and dense algal growth can reduce the suitability of the habitat, reducing the diversity of species that can live in the habitat.

In many rivers, organic material from riparian vegetation forms the major basis of the in-stream food chain. High flows are therefore required to sweep organic material off in-channel benches. Ideally, these should occur in late autumn to early winter, as organic material would have been partly processed during the warmer summer months.

The flow requirements to achieve the aquatic macroinvertebrate objectives are summarised in Table 3.6. Included in the table are a number of criteria which will be used to determine magnitude, timing, frequency and duration of flows.

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[22] The number of invertebrate families found in streams can give a reasonable representation of the ecological health of a stream - healthy ecosystems generally have more families.

[23] SIGNAL is an index of water quality based on macroinvertebrate tolerance or intolerance to pollution. The SIGNAL Score is a number between zero and ten, reflecting the degree of water pollution - high quality sites have high SIGNAL scores.

[24] AUSRIVAS is a predictive model for comparing the similarity of the invertebrate community of a sampled site to minimally disturbed reference sites. The higher the score, the more natural the community. Band A means similar to reference, while B is somewhat below reference etc.

[25] Numbers of families from Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies), generally considered groups sensitive to disturbance.

[26] A list has been prepared of typical macroinvertebrate families that should be found in Forest-B segments if they are in healthy condition. This objective is not measured if an AUSRIVAS score is available.

Table 3.6 Summary of flow requirements to achieve aquatic macroinvertebrate objectives in Painkalac Creek

Objective	Flow Function	Flow Components	Timing	Criteria
Restore macroinvertebrate communities to meet SEPP (Waters of Victoria) environmental quality objectives for Forest-B segments.	Maintain habitat in pools	Low Summer Flow Low Winter Flow	All year	Lower parts of edge vegetation permanently inundated
	Maintain habitat in runs	Low Summer Flow Low Winter Flow	All year	Lower parts of edge vegetation permanently inundated (run depth >10 cm)
	Flush sediments from habitat surfaces	Low Flow Freshes High Flow Freshes	All Year	Mean channel scour in pools and runs >1.4 Nm^{-2}
	Prevent dominance of filamentous algae	High Flow Freshes	Winter-Spring	Mean channel velocity in pools >0.3 $msec^{-1}$
	Prevent water quality decline	Low Flow Freshes	Summer-Autumn	Positive average velocity in pools

3.6 Vegetation

3.6.1 Catchment scale vegetation types

Before European settlement, Painkalac and Distillery Creeks flowed through a complex mix of EVCs (Ecological Vegetation Classes), including[27]:

- Riparian Forest (EVC 18) and Sedgy Riparian Woodland (EVC 198) along creek sides;
- Swampy Riparian Woodland (EVC 83) in nearby low-lying areas;
- Lowland Forest (EVC 16), Shrubby Dry Forest (EVC 21) and Heathy Woodland (EVC 48) in more elevated areas;
- Shrubby Foothill Forest (EVC 45) on higher land to the west; and
- Coastal Tussock Grassland (EVC 163) along the estuarine parts of the creek.

Currently the main EVCs in the study region include:

- linear strips of Riparian Forest (EVC 18) and Sedgy Riparian Woodland (EVC 198) along creeks;
- Swampy Riparian Woodland (EVC 83) along Distillery Creek and in small patches downstream of the Painkalac Creek-Distillery Creek confluence;
- large areas of Lowland Forest (EVC 16) and Shrubby Dry Forest (EVC 21) to the north and south of the creek;
- a strip of Shrubby Foothill Forest (EVC 45) extending up a creekline near Dam Road, just downstream of the Painkalac Reservoir;
- Heathy Woodland (EVC 48) found in large areas just south of Painkalac Creek; and
- Coastal Tussock Grassland (EVC 163) near the estuarine mouth.

The distributions of these various EVCs aligns approximately with patterns of land tenure in the catchment. A large extent of the highland sections upstream of Painkalac Reservoir, is located in the Great Otway National Park. Vegetation in Park ranges from cool temperate rainforest to dry heathland, reflecting changes in climate, aspect, soil and fire history[28]. The northern area of the Park

[27] Information from Biodiversity Interactive Map online at www.nremap-sc.nre.vic.gov.au/Mapshare.V2/imf.jsp?site=bnr-V1

[28] Forsyth, D.A. and Ransome, S.W. (1978). *A report on the Painkalac Creek (Aireys Inlet) catchment*. Report to Soil Conservation Authority, Kew.

around Aireys Inlet is one of the drier regions and vegetation consists mostly of a mixture of heathland and dry sclerophyll forest. The heathlands in particular are among the most diverse vegetation communities in Victoria: 282 native plant species, including 46 species of orchid, have been reported in an area of only 226 ha near Anglesea[29].

3.6.2 Vegetation of the study site

Four vegetation-habitat types were observed when the study reach was examined in July 2007:

- In-stream submerged vegetation;
- Biofilms of algae, fungi and bacteria on coarse woody debris;
- In-stream and fringing emergent vegetation, sometimes rooted in the stream bed but mostly on benches and on the lower levels of the river bank; and
- Woody riparian vegetation on the stream banks.

In-stream submerged vegetation was neither widespread nor dense, but isolated beds of what seemed to be young Water Ribbons (*Triglochin procerum*) were seen in parts of the stream (Figure 3.4). The general absence of submerged plants is perhaps not unexpected, given the heavy shading provided by the dense fringe of riparian trees and the recent very low water levels.

Figure 3.4 In-stream vegetation, possibly young Water Ribbons, in Painkalac Creek

The abundant eucalypts in the riparian zone contributed to a large amount of coarse woody debris in the stream which provides a substratum for the development of microbial biofilms. These biofilms provide high-quality food for a range of aquatic consumers, including snails and other macro-

[29] Parks Victoria (1999). *Angahook-Lorne State Park Management Plan*.

invertebrates[30, 31]. These biofilms must be wetted episodically to maintain productivity, and subject to episodic scouring to prevent largely inedible filamentous algae from dominating the algal components.

Emergent vegetation was present on raised benches along the stream (Figure 3.5). Three species observed were Spike Rush (*Eleocharis spacelata*), Common Reed (*Phragmites australis*) and an un-identified species of rush (*Juncus* sp.).

Although only these three species were observed on the field day, the bioregional EVC descriptions indicate that a wide range of other emergent aquatic plants could occur in the near vicinity, including rushes such as *Juncus planifolius* and *Juncus pallidus*, sedges such as *Carex appressa* and *Cyperus lucidus*, and possibly sword sedges such as *Lepidosperma laterale* var *majus*. As with the submerged vegetation, it is possible that the recent drought and low water levels may have limited the extent and abundance of emergent aquatic vegetation.

Figure 3.5 Beds of Spike Rush on benches in Painkalac Creek.

The predominant type of woody riparian vegetation along the study reach of Painkalac Creek was Riparian Forest (EVC 18). This vegetation class is characteristically a tall forest associated with river banks and old alluvial terraces. The soils are fertile and, because they are regularly inundated, permanently moist. Manna Gum (*Eucalyptus viminalis*) is the dominant canopy tree.

As noted in the Site Paper, two other riparian EVCs are found in or near the study region: Swampy Riparian Woodland (EVC 83) and Sedgy Riparian Woodland (EVC 198). These are characterised by Swamp Gum (*Eucalyptus ovata*) and mixed Swamp Gum and Messmate Stringybark (*Eucalyptus*

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[30] Bunn SE and Boon PI (1993). What sources of organic carbon drive food webs in billabongs?: a study based on multiple stable-isotope analysis. *Oecologia* 96: 85-94.

[31] Scholz O and Boon PI (1993). Biofilms on submerged River Red Gum (*Eucalyptus camaldulensis* Dehnh., Myrtaceae) wood in billabongs: an analysis of bacterial assemblages using phospholipid profiles. *Hydrobiologia* 259: 169-178.

obliqua), respectively, as canopy trees. A wide range of understorey trees and shrubs are present in these three riparian EVCs, including Blackwood (*Acacia melanoxylon*), Black Watttle (*Acacia mearnsii*), Prickly Moses (*Acacia verticillata ssp. verticillata*), Scented Paperbark (*Melaleuca squarrosa*) and Woolly Teatree (*Leptospermum lanigerum*). Of note is that Showy Lobelia (*Lobelia beaugleholei*), a rare[32] small terrestrial herb, is listed as present in the generic description of the Swampy Riparian Woodland EVC (EVC 83). However, this EVC is widely distributed and Showy Lobelia may not be present in all occurrences of the EVC. Feedback from the Reference Group indicates that the nearest documented record of Showy Lobelia is in the Port Campbell area.

Figure 3.6 shows a typical view of the riparian vegetation of the study site.

The Site Paper concluded, on the basis of the report by Saw (2005)[33], that willows characterised the riparian zone of agricultural sections of Painkalac Creek. This report appears to be incorrect as we found willows were not present in the study reach. The other common weed in these EVCs, blackberries (*Rubus fruticosus* spp. *agg.*), were also absent from riparian zones that bordered agricultural land due to diligent weed control by the landholder. The absence of these two notorious weeds would contribute positively to the maintenance and rehabilitation of the riparian zone.

Figure 3.6 Eucalypt-dominated riparian vegetation along Painkalac Creek. Both banks are subject to grazing and stock access.

3.6.3 Environmental objectives for vegetation

Four Environmental Objectives for vegetation in the study reach of Painkalac Creek are proposed:

[32] DSE (2005) Advisory list of rare or threatened plants in Victoria. Department of Sustainability and Environment, Melbourne.

[33] Saw, D. (2005). Painkalac Creek catchment area: a land use investigation. *Interaction* (Journal of the Geography Teachers' Association of Victoria Inc) **33**: 35-42.

- *Maintain and enhance healthy and diverse communities of native aquatic vegetation in the in-stream and fringing zones.*
- *Maintain and enhance biofilms on submerged surfaces, particularly coarse woody debris.*
- *Maintain and enhance healthy and diverse communities of native vegetation in the riparian zone.*
- *Entrain terrestrial organic matter from the benches into the stream.*

3.6.4 Flow requirements for vegetation objectives

Restoring aquatic, emergent and fringing vegetation requires a mixture of flow components of various stage heights, durations and timing. As submerged aquatic vegetation is generally intolerant of complete drying, it requires a suitable low flow through-out the year to maintain pools of permanent water. Similarly, emergent aquatic vegetation such as the rushes, reeds and sedges that grow along the edges of the pools and on slightly raised benches in the main channel requires wet soil; the base flow must be sufficient to keep the deeper soil layers of these habitats moist even during summer. These flows could well be vital to allow aquatic plants to recolonise the stream after the recent drought period.

Periodic freshes during summer are required for a number of ecological functions. First, they are needed to inundate higher benches and provide water to emergent vegetation growing on these slightly elevated areas. Second, these summer-autumn freshes may be important in mixing the deeper pools that occur in the main channel of the stream and preventing the formation of bottom waters with very low in dissolved oxygen. Third, summer-autumn freshes are useful in periodically wetting the microbial biofilms that grow on coarse woody debris in the stream and provide food (especially algae) for a wide range of aquatic animals. Finally, freshes are effective in mobilizing terrestrial plant debris such as leaves, twigs and bark that has fallen from riparian trees and shrubs; once moved into the stream channel this material provides long-term food for a wide range of aquatic animals. The importance of terrestrial organic matter in supporting aquatic food webs has been discussed earlier in the section on macroinvertebrates.

Freshes are required also in winter-spring to inundate benches in order to provide water to emergent vegetation. These winter-spring freshes also have a role in minimizing the colonization of nominally aquatic habitats by terrestrial vegetation, especially pasture grasses. The shade provided by dense riparian vegetation will help control invasion of these aquatic zones by terrestrial plants. As with the summer-autumn freshes, higher flows during winter-autumn are required to wet the biofilms that grow on woody debris that has fallen into the stream and to mobilize terrestrial plant litter from surrounding riparian zones.

Much higher flows – bankfull flows – are needed to maintain moist soil conditions for trees, shrubs and understory plants growing in the riparian zone. The predominant type of woody riparian vegetation are Riparian Forest (EVC 18), Swampy Riparian Woodland (EVC 83) and Sedgy Riparian Woodland (EVC 198), all of which is characteristically by poorly drained, permanently moist and fertile soils. The precise water requirements for these vegetation types are less well known than are requirements for eucalypts such as River Red Gum (*Eucalyptus camaldulensis*), but bankfull flows should maintain the damp soil conditions required for key species such as Swamp Gum (*Eucalyptus ovata*).

The flow requirements to achieve the vegetation objectives in Painkalac Creek are summarised in Table 3.7. Included in the table are a number of criteria which will be used to determine magnitude, timing, frequency and duration of flows.

Table 3.7 Summary of flow requirements to achieve vegetation objectives in Painkalac Creek

Objective	Flow function	Flow components	Timing	Criteria
Maintain and enhance native aquatic vegetation in in-stream and fringing zones	Maintain pool depth in summer for plant habitat	Low Summer flow	Summer/Autumn	Pool depth > 20 cm
	Prevent water quality decline	Low Flow Freshes	Summer/Autumn	Positive average velocity in pools
	Inundate bars to wet emergent vegetation and maintain moist soils	Low Flow Freshes	Summer/Autumn	Benches inundated for *ca* 1-3 days
	Maintain pool and run depths for plant habitat	Low Winter flow	Winter/Spring	Pool and run depth > 20 cm
	Inundate benches and bars to prevent colonisation by exotic or terrestrial plant taxa	Low Winter Flow High Flow Freshes	Winter/Spring	Benches and bars inundated for *ca* 1+ week
Maintain and enhance native riparian vegetation	Maintain moist soils in riparian zones	Bankfull and/or overbank	Winter/Spring	Sufficient to maintain wetted soil zone at top of bank
Maintain and enhance biofilms on submerged surfaces	Episodically wet exposed coarse woody debris	Low Flow Freshes	Summer/Autumn	Wood inundated *ca* 1 day
	Episodically wet exposed coarse woody debris and remove accumulated algal growth	High Flow Freshes and/or Bankfull	Winter-spring	Wood inundated *ca* 1-3 days by high-velocity water
Entrain terrestrial organic matter into the stream	Move terrestrial leaves, bark and wood into the stream from surrounding areas	Low Flow Freshes	Summer-autumn	Inundate low-lying benches
	Move terrestrial leaves, bark and wood into the stream from surrounding areas	High Flow Freshes	Winter-spring	Inundate higher level benches

3.7 Water Quality

No permanent water quality monitoring station has been established in the freshwater reach of Painkalac Creek. Water quality has been measured upstream of the reach at the Painkalac reservoir site (Station 235232), but it would appear this was discontinued in 1987.

GHD (2005) reviewed previous intermittent water quality records for the creek, few of which have been conducted in the study reach. They concluded that "none of the parameters that have been measured at this site …" [Old Coach Road] … "in the past were consistently outside of ANZECC guidelines." (p. 13).

GHD (2005) also sampled a number of water quality parameters in 2005 at the Old Coach Road site, at the lower extent of the freshwater reach – *E. coli*, *Enterococci*, nitrogen, phosphorous, BOD, Electrical conductivity, dissolved oxygen, pH and turbidity.

They concluded that dissolved oxygen levels at the site were "well below the recommended levels for supporting diverse aquatic biota" (p. 18) and that nitrogen levels and *Enterococci* levels were both high. All other parameters were within ANZECC guidelines, although "the overall water quality at this site appears to have decreased since the previous studies" (p. 18).

They seem to attribute this decline to upstream land use:

> *The land upstream of this site is privately owned farmland that is used for cattle and horses, which have access to the creek. In many places the creek and riparian zone is severely degraded and denuded. This would certainly increase erosion of the banks and surrounding landscape, and contribute to elevated sediment and nutrient load and turbidity of the creek during rainfall events.* (p. 18).

It is not intended in this study to recommend flows to improve water quality in Painkalac Creek where the cause is due to catchment conditions, as it is considered more desirable to solve water quality issues at their source, rather than use valuable water resources. However, flows that prevent flow related water quality decline will be included in the recommendations.

4. Summary of Flow Requirements

The following tables summarise the flow requirements to achieve all of the environmental objectives in Painkalac Creek. The recommendations to be developed in Stage 2 will be identified to achieve all of these flow components with more precise timing, frequency and duration.

Note: Months that comprise the Low and High Flow Seasons will be determined from the natural flow data when available.

<table>
<tr><th colspan="6">Low Flow Season (generally December to May)</th><th colspan="6">High Flow Season (generally June to November)</th></tr>
<tr><td colspan="6">Low Flow for:
fish, macroinvertebrate and plant habitat.</td><td colspan="6">Low Flow for:
• fish, macroinvertebrate and plant habitat.
• inundate low bars and benches to deter terrestrial plant encroachment</td></tr>
<tr><td colspan="6">Low Flow Freshes to:
• maintain quantity and quality of key habitats.
• maintain summer/autumn water quality.
• allow localised fish recolonisation.
• inundate low level benches/bars for semi-aquatic vegetation.
• wet exposed coarse woody debris to maintain biofilm communities.
• move organic terrestrial material to stream.</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="6">Low Flow Freshes for:
• localised fish movement prior to freshwater breeding (Spotted and Broad-finned galaxias).
• prepare fish breeding habitat (Spotted and Broad-finned galaxias).</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="6">Transitional Season Freshes to:
• stimulate spawning (Spotted and Broad-finned galaxias).
• stimulate migration (Common galaxias, Tupong).</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="5">High flows to:
• wash larvae to sea (Spotted and Broad-finned galaxias).
• allow migration to estuary (Common galaxias, Tupong).</td><td></td><td></td><td></td><td></td></tr>
</table>

Low Flow Season (generally December to May)						High Flow Season (generally June to November)					
						High Flow Freshes to: • maintain bed diversity for water depth variation. • inundate high level benches to prevent colonisation by terrestrial plants and promote restoration of natural bench vegetation zonation. • remove accumulated filamentous algal growth from surfaces. • flush sediment from habitat surfaces. • wet exposed coarse woody debris to maintain biofilm communities. • move organic terrestrial material to stream.					
						Bankfull flows to: • maintain channel form and key habitats. • wet soil at top of bank for riparian maintenance. • inundate high level benches to prevent colonisation by terrestrial plants and promote restoration of natural bench vegetation zonation.					
						High Flow Freshes to: • prepare non-migratory fish breeding habitat (Australian Smelt, Flat-headed gudgeon).					
							High Flow Freshes for: • non-migratory species movement prior to breeding (Australian Smelt, Flat-headed gudgeon).				
								High Flows for: • upstream migration of juvenile fish and lamprey.			
Anytime - **Bankfull** flow for: • channel maintenance.											
Anytime - **Overbank** flow for: • connectivity with important floodplain and anabranch zones.											

5. Other Catchment Issues

5.1 Grazing

Almost all of the study reach is grazed on at least one bank. Grazing has a number of recognised impacts on stream ecosystems[34,35] including:

- the prevention of recruitment of native trees and shrubs, leading to the replacement of native tree and shrub species along the riparian zone with grassy groundcover species, often including pasture escapees (the lack of recruitment and grassy groundcover can be seen in Figure 3.6).

- soil compaction and erosion of banks. This can prevent the establishment of juvenile native plants in the riparian corridor and the delivery of additional sediment to the stream system.

- an increase in the amount of phosphorous and nitrogen in the stream water from manure and urine. This can lead to an increase in the growth of nuisance plants and algae, reducing the habitat suitability in the stream.

- the introduction of exotic pasture grasses and weed species via animal dung. Through the process of selective herbivory, it can lead also to the over-consumption of palatable species, such as sedges, and their replacement by tougher and less easily consumed species.

Having said that, the landholder has commendably introduced a number of actions to ameliorate the impacts of grazing including a control on the number of stock, the provision of reticulated water points in all paddocks which stock preferentially use, the introduction of 8 species of dung beetle to minimise faecal contamination of the creek (Graeme McKenzie, landholder, pers. comm.).

However, it needs to be acknowledged that maximum ecological benefits from environmental flows will be realised only if control is exercised over grazing and stock access to the riparian zone and creek to allow rehabilitation of the vegetation.

This issue has been recognised in the Estuary Management Plan (Surf Coast Shire, undated) with the actions proposed to:

- *Fence and rehabilitate riparian areas on private land in the Painkalac Creek catchment*; and
- *Fence and rehabilitate riparian areas on Council owned and managed land in the Painkalac Creek catchment*. (Objective 1, p. 24).

The landholder considers that fencing may not be suitable in his part of the creek, due to the potential for damage during floods (300 m of test fencing was constructed in August/September 2007, 200 m of which was destroyed in the flood on November 2007). Should rehabilitation of the riparian zone be seen as desirable, alternative approaches may need to be investigated and implemented.

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[34] Staton J and Sullivan J (2006). *Stock and waterways: a manager's guide*. Land and Water Australia, Canberra.**3**: 35-42.

[35] LWA (2002) *Managing Stock*. River Landscapes Fact Sheet No. 6. Land and Water Australia, Canberra.

5.2 Large Woody Debris

Large Woody Debris (LWD) is of considerable importance in maintaining channel form, stability and habitat niches. LWD reduces the energy of the flow which reduces the potential for bank erosion. LWD also encourages bed scour which maintains diversity in the bed form and variation in water depth for habitat, which is particularly evident in Painkalac Creek. Removal of LWD should be prevented, unless otherwise demonstrated as a serious threat to a high value asset or human life. Riparian stands providing potential future sources of LWD should be maintained or regenerated.

5.3 Fish passage

In order to achieve the objective of restoring the populations of native migratory fish species, it is necessary to have clear fish passage at the appropriate times of the year for adults or juvenile fish.

The State Fishway Program inventory of barriers to fish passage[36] lists three artificial barriers to fish passage in Painkalac Creek – all designated as "stream gauging stations". Two of these refer to Painkalac reservoir and the associated gauging station at the top of the reach, while the third is unknown (located at grid reference 246900E 5740300N).

A second issue is the recently constructed stream grade control structure immediately downstream of the Old Coach Road crossing (Figure 3.3). This potentially forms a barrier to movement as there is no clear path of surface water for fish to move through. Transects have been established across the structure and flows to allow fish movement will be investigated.

5.4 Climate Change

The provision of water for both environment and consumptive use needs to be considered in the context of potential climate change. Predicted reductions in rainfall will mean less flow in affected rivers. CSIRO[37] estimates for the Otway Coast suggest a reduction in runoff between 5% and 30% by the year 2030.

The environmental flow recommendations to be developed as part of this study should be seen as independent of climate change – the requirements of the in-stream and riparian flora and fauna will not change with the climate. However, the amount of water available to satisfy both environmental and consumptive uses will decline to some degree, which may present a challenge to the Painkalac Creek community in the future.

[36] McGuckin, J. and Bennett, P. (1999) *An inventory of fishways and potential barriers to fish movement and migration in Victoria*. Department of Natural Resources and Environment, Melbourne.

[37] Jones, R.N. and Durack, P.J. (2005) Estimating the impacts of climate change on Victoria's runoff using a hydrological sensitivity model. CSIRO, Melbourne.

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www.nremap-sc.nre.vic.gov.au/Mapshare.V2/imf.jsp?site=bnr-V1 (Biodiversity Interactive Map)