AN ASSESSMENT OF ENVIRONMENTAL FLOW REQUIREMENTS FOR THE OLINDA CREEK CATCHMENT

for
Melbourne Water
Waterways and Drainage

by

Paul Close and Wayne Koster

Natural Resources and Environment

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Cover photographs (top to bottom): Headwaters of Olinda Creek at Kalorama.
All photos by Paul Close Gauging station at York Road, Mt Evelyn.
Lower reaches of Olinda Creek near Coldstream.

Summary

Background

The State Environmental Protection Policy (Waters of Victoria) Schedule F7 (Waters of the Yarra Catchment) specifies that Streamflow Management Plans (SMP's) are to be developed for waterways in the Yarra Catchment (EPA 1999). SMP's are intended to create a balanced and sustainable sharing of available water between all stakeholders with the aim of providing a long-term management strategy for water use that includes provisions for the maintenance and/or restoration of environmental values within the system. In the Olinda Creek catchment stakeholders include, the environment, licensed diverters, and non-consumptive water use (recreation and aesthetics).

As a component of the Olinda Creek SMP, **Freshwater Ecology (Department of Natural Resources and Environment)** has been commissioned to conduct an environmental flow study for the Olinda Creek catchment. The Olinda Creek catchment is located about 35 kilometres east of Melbourne and drains a catchment of approximately 82 km^2. The area covered by this SMP includes Olinda Creek mainstem from the headwaters downstream to the junction of the Stringybark sub-catchment.

This document represents the final component of a three-phase environmental flow study conducted as part of the Olinda Creek SMP. This report details findings and outcomes for each of the three phases as described below.

- ***Phase 1*:** Understanding the system and recommending environmental management objectives
  - Identify significant environmental values
  - System management
  - Review/assess hydrology
  - Develop environmental management objectives
- ***Phase 2:*** Field assessment for environmental flow recommendations
  - Habitat availability assessments
- ***Phase 3:*** Environmental recommendations

Environmental Values

Environmental values in the Olinda Catchment were identified and described in terms of flora and fauna with conservation significance. Ten species of fish (four native and six exotic) and two species of decapod crustacean have been recorded although none are considered threatened in Victoria (DNRE 2000d). Upper reaches of Olinda Creek support a diverse range of macroinvertebrates including freshwater amphipod (*Austrogammarus australis*) (Papas *et al.* 1999) which is classified as 'insufficiently known' in Victoria (DCNR 1995) and is listed on the Victorian *Flora and Fauna Guarantee Act* 1988. Approximately 22 species of reptile and 11 species of amphibian have been recorded, of which three species are considered threatened in Victoria. These are the warty bell frog (*Litoria raniformis*) and swamp skink (*Egernia coventryi*), both of which are classified as vulnerable, and the lace monitor (*Varanus varius*), which is classified as data deficient (DNRE 2000d). The Olinda Creek Catchment supports approximately 168 native bird species and 31 native mammal species (DNRE 2000b). A number of these native vertebrates are considered threatened in Victoria, including one critically endangered, seven endangered and nine vulnerable species. There are also ten species listed on the Victorian *Flora and Fauna Guarantee Act* 1998 (DNRE 2000d). A number of the threatened bird species are listed on international treaties. One bird species, the regent honeyeater *Xanthomyza phrygia*, is listed as critically endangered on the Australian and New Zealand Environment and Conservation Council *List of Threatened Australian Vertebrate Fauna* (DNRE 2000d). Approximately 254 native species of aquatic and riparian flora have been recorded. Four of these species are considered threatened in Victoria (Gullan *et al.* 1990, DNRE 2000c); the swamp bush pea (*Pultanaea weindorferi*), classified as rare, the tussock sedge (*Carex iynx*) and Yarra gum (*Eucalyptus yarraensis*) classified as poorly known, and the Buxton Gum (*Eucalyptus crenulata*) classified as endangered. The swamp bush pea and Yarra gum are also classified as rare in Australia, and the Buxton gum is classified as endangered in Australia (Gullan *et al.* 1990).

Hydrology, System Management and Alterations to the Natural Flow Regime

Olinda Creek is approximately 25 km in length and drains a catchment of approximately 82 km^2. Mean annual rainfall in the catchment is approximately 1000 mm (Rowan 1982). Stream flows in Olinda Creek are seasonal with the low flow months identified as January through to May and high flow months from August through to November.

Both surfacewater and groundwater harvesting occurs in the Olinda Creek catchment for commercial and domestic and stock use (Richards 1999). There are currently 67 licensed diversion permits on Olinda Creek with a total licensed volume of 747 $ML.yr^{-1}$ (Melbourne Water unpublished data, Doeg 1999). Sixty-nine percent of licensed diversions are above Lilydale Lake. The majority of licensed diversions are for irrigation and represent approximately 70 % (503 $ML.yr^{-1}$) of the total licensed volume for the catchment. There are two main water storages within the Olinda Creek catchment. Lilydale Lake is essentially a transparent storage that is used primarily for recreational purposes (inflows equal outflows; Steve Nicol, Melbourne Water *pers. comm.*). Silvan Reservoir is located adjacent to the upper reaches of Olinda Creek and does not receive any water harvested from the Olinda Creek catchment. A minimum environmental flow of 2ML.day^{-1} is however released from Silvan Reservoir into Olinda Creek (Pettigrove and Hall 1999).

The flow regime of Olinda Creek has been altered by diversion of water for a variety of uses. This is especially true over the low flow period (January – May) and in the upper reaches of the catchment, upstream of Lilydale Lake. Over the low flow period the magnitude of mean passing flows has decreased by approximately 20-30% from natural flows. Urban developments have also affected the flow regime of Olinda Creek, increasing the area of impervious surfaces leading to increased volume of run-off and size of the flood peak from rainfall events (Richards 1999, Walsh and Breen 1999). Substantial discharges from Lilydale Purification Plant, downstream of Lilydale, contribute to environmental flows during dry periods (Pettigrove and Hall 1999).

Relatively few water quality data are available for Olinda Creek compared with other waterways in the Yarra catchment. The limited available data suggest a large increase in nutrients and suspended solids downstream of Lilydale. Lilydale Purification Plant is considered a major source of nutrients and other pollutants to Olinda Creek (Pettigrove and Hall 1999). Dissolved oxygen concentrations are generally low in the lower reaches of Olinda Creek, although levels do comply with State Environment Protection Policy objectives (EPA 1997). Heavy metals were below ANZECC/ARMCANZ (1999) interim sediment quality guidelines (ISQG) at most sites although lead, nickel and zinc exceeded the ISQG guidelines.

Stream Condition

In general, the environmental condition of instream and riparian areas within the Olinda Creek catchment is regarded as moderate to poor (Chesterfield and Sovitslis 1994). Stream bed siltation is evident along the entire length of Olinda Creek, stream bed degradation occurs in discontinuous but lengthy reaches, and weed infestations occur throughout most of the catchment (ID&A 1999). Assessment of stream condition based on the Index of Stream Condition (ISC) indicate environmental condition is best upstream of Mt Evelyn township where, despite some sections of weedy infestations, riparian vegetation is relatively intact and instream habitats are diverse and complex (ID&A 1999). Stream condition decreases in the reach downstream of Mt Evelyn to Lilydale where riparian vegetation is highly disturbed and moderate siltation of the stream bed, bank undercutting and erosion occur. Downstream of Lilydale to the Yarra River confluence, stream condition is poor (ID&A 1999). Riparian vegetation is extremely degraded and instream habitat is scarce and largely restricted to overhanging exotic vegetation. Stream channelisation is extensive, and moderate stream bed siltation, bank incision, slumping and erosion also occur (ID&A 1999). SIGNAL scores indicate macroinvertebrate populations tend to be dominated by families highly sensitive to pollution in the upper catchment (SIGNAL score at Mt Evelyn - 6.38) and that families more tolerant to pollution become more abundant with increasing distance downstream (SIGNAL score at Coldstream - 5.27) (Bessell-Browne 2000).

Environmental Management Objectives

The following management objectives apply specifically to the management of stream flows in Olinda Creek.

1. *Maintain appropriate minimum environmental flows over the low flow period.*

2. *Provide appropriate flushing flows and high flow regimes that provide suitable conditions for migration and spawning of native fish species and essential geophysical processes such as channel scouring and silt removal.*

3. *Maintain water quality in accordance with SEPP (Waters of Victoria) – Schedule F7 Waters of the Yarra Catchment (EPA 1999), including provision of summer flushing flows.*

4. *Ensure that winter-fill diversions are set at a level that does not impact on essential biological and geomorphological processes.*

In addition, several management objectives specifically apply to biodiversity conservation.

1. *Maintain and/or restore diversity and complexity of instream habitat (e.g. woody debris).*

2. *Maintain and/or enhance diversity of aquatic fauna species and encourage recolonization of Olinda Creek by migratory species.*

3. *Provide unimpeded fish access throughout the Olinda Creek system through removal of instream barriers.*

Habitat Availability and Environmental Flow Recommendations

Minimum environmental flows are recommended for Olinda Creek based on an assessment of historical flow data (natural and current regimes), fish habitat availability and expert opinion. These recommendations aim to meet the environmental management objectives listed above. The precautionary principle (i.e. a suitable ecological safety margin) has been applied due to our limited knowledge of the relationship between flow regimes and the ecology of native freshwater fish in Olinda Creek.

Minimum environmental flows are recommended for each site at which habitat surveys were undertaken. As approximately 70% of licensed diversions are located above Lilydale Lake and, as derived natural flows are available for the Mt Evelyn gauging station (229609), site specific recommendations are referenced to the Mt Evelyn gauge. A minimum environmental flow is therefore recommended for Mt Evelyn gauge (229609) which should meet the environmental management objectives (listed above) for each site.

Minimum environmental flow recommendations for three sites on Olinda Creek.

Site location	Environmental Flow ($ML.day^{-1}$)
Site 1 Olinda Creek at Kalorama	2
Site 2 Olinda Creek at Mt Evelyn*	**6**
Site 3 Olinda Creek at Lilydale	15

*, compliance point

Rules for winter-fill volumes and rates are currently being developed as a component of a sustainable diversion limits project being undertaken by the Department of Natural Resources and Environment. Recommendations that are developed through this project can be applied to the Olinda Creek system when completed.

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1. INTRODUCTION

Alteration to the natural flow regimes of rivers and streams is considered a major threat to the health of waterways, aquatic flora and fauna communities and the maintenance of essential instream ecosystem processes (SAC 1992). For example, alterations to key components of the flow regime including flow magnitude, seasonality and variability are regarded as key factors responsible for the decline in distribution and abundance of many native freshwater fish species throughout Victoria (Koehn and O'Connor 1990). Altered flow regimes have been identified as a potentially threatening process under the Victorian *Flora and Fauna Guarantee Act 1988* (SAC 1992) and are nominated as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999*.

Melbourne Water, being the authority responsible for waterway management in the Yarra catchment, is required to develop a Streamflow Management Plan (SMP) for Olinda Creek as part of the State Environment Protection Policy (Waters of Victoria) Schedule F7 (Waters of the Yarra Catchment) (EPA 1999, Richards 1999). SMP's are intended to create a balanced and sustainable sharing of available water between all stakeholders which in the Olinda Creek catchment include, the environment, licensed diverters, and non-consumptive water use (recreation and aesthetics). The aim of a SMP is to provide a long-term management strategy for water use that includes provisions for the maintenance and/or restoration of environmental values within the system. The development of a SMP for the Olinda Creek system will enable Melbourne Water to:

- Clarify rights to water resources;
- Ensure the long term sustainability of the river system by reaching a balance between environmental requirements and consumptive uses of the water;
- Provide a framework of rules to operate the river system to meet agreed water management objectives and;
- Ensure that future development does not have a negative impact on existing water users and the environment.

As a component of the Olinda Creek SMP, **Freshwater Ecology (Department of Natural Resources and Environment)** was commissioned to undertake an environmental flow study and determine appropriate minimum environmental flows for the Olinda Creek catchment. The broad objectives of the study were to:

- Identify significant environmental values that need to be protected by adequate flows.
- Identify other significant impacts on environmental values.
- Recommend environmental management objectives.
- Comment on the biological significance of changes to the flow regime (natural versus regulated).
- Recommend environmental flows at a number of specified points within the system.

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2. STUDY AREA

The Olinda Creek catchment is located about 35 kilometres east of Melbourne and drains a catchment of approximately 82 km^2 (Doeg 1999) (Figure 2-1). Olinda Creek is approximately 25 km in length with the headwaters rising at an altitude of 540 metres above sea level near Olinda in the Dandenong Ranges National Park. From its headwaters the creek flows in a northerly direction for approximately seven kilometres through steep slopes of palaeozoic igneous and metamorphic rocks and quaternary volcanic plains (Rowan 1982, Melbourne Water Corporation 2000) before reaching the urban township of Mount Evelyn. Upper reaches of the catchment support areas of dry and wet sclerophyll forest, wet gullies with tree ferns, and swamp gum communities (Rowan 1982, Melbourne Water Corporation 2000). Downstream of Mt Evelyn the creek continues in a northerly direction for approximately seven kilometres through hilly and undulating lands of Palaeozoic sedimentary rocks which support the pasturelands and orchards of Lilydale. The creek then flows for approximately 11 kilometres through quaternary alluvial plains supporting pasture lands and viticulture areas around Yering prior to its confluence with the Yarra River (Rowan 1982, Melbourne Water Corporation 2000). The lower sections of Olinda Creek consist of a relatively straight channelised stream. Mean annual rainfall in the catchment is approximately 1000 mm (Rowan 1982). Townships in the catchment include Olinda, Mount Dandenong, Mount Evelyn, Lilydale, Coldstream and Yering (Figure 2-1).

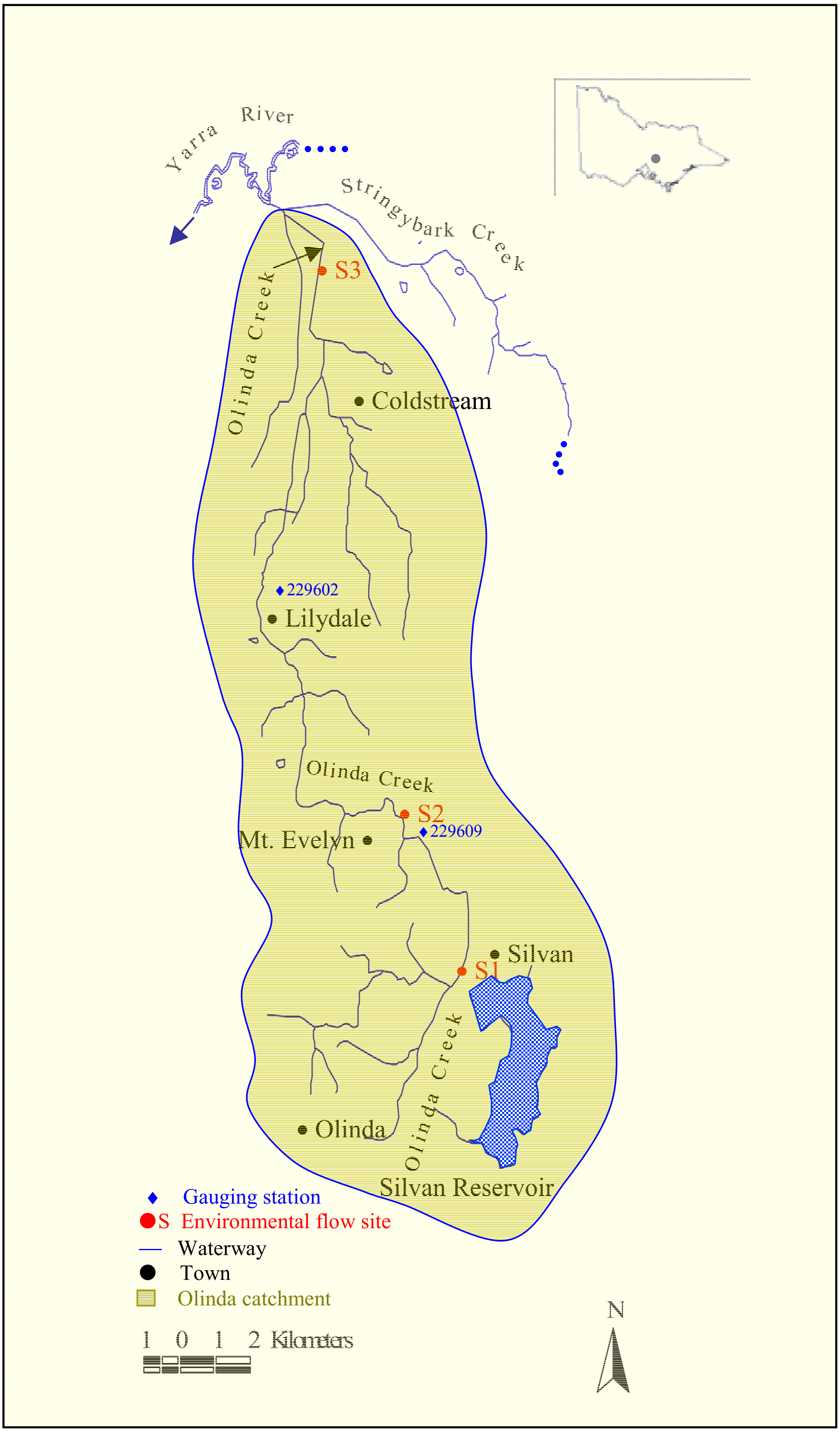

Figure 2-1. Location of environmental flow sites, gauging stations and other major reference points in the Olinda Creek catchment.

3. ENVIRONMENTAL VALUES OF THE OLINDA CREEK CATCHMENT

Environmental values in the Olinda Catchment were identified and described in terms of flora and fauna with conservation significance. A review of literature, the Victorian Fish Database (DNRE 2000a), the Atlas of Victorian Wildlife (DNRE 2000b) and the Victorian Flora Information System (DNRE 2000c) was undertaken to determine the distribution and diversity of significant biota that occur in the Olinda Creek catchment.

3.1 Fish

Ten species of fish (four native and six exotic) and two native species of decapod crustacean have been recorded in the Olinda Creek catchment (Hannon *et al.* 1999, Williams *et al.* 1999, DNRE 2000a) (Table 3-1). None of the native species are considered threatened in Victoria (DNRE 2000d). In the upper reaches of the catchment, native fish species are predominant in fish assemblages, although the exotic brown trout is also common. Throughout the middle and lower reaches of the creek, exotic fish species are prevalent. European carp and oriental weatherloach were recorded in the lower reaches of the creek in 1997, just upstream of the Yarra River confluence (Melody Serena 2000 *pers. comm.* Australian Platypus Conservancy). This is the only documented record of these species in Olinda Creek although the distribution and abundance of these exotic species may have since increased.

Table 3-1. Native and exotic fish species and decapod crustacea recorded in the Olinda Creek catchment, including their conservation status (DNRE 2000a).

Scientific Name	Common Name	Distribution in catchment	Conservation Status
Non migratory native fish species			
Gadopsis marmoratus	River blackfish	Upper reaches	C
Galaxias olidus	Mountain galaxias	Mid to upper	C
Migratory native fish species			
Anguilla australis	Short-finned eel	Upper to lower	C
Galaxias maculatus	Common galaxias	Lower reaches	C
Exotic fish species			
Cyprinus carpio	Carp	Lower reaches	-
Gambusia holbrooki	Eastern gambusia	Mid to lower	-
Misgurnus anguillicaudatus	Oriental weatherloach	Lower reaches	-
Perca fluviatilis	Redfin	Lower reaches	-
Rutilus rutilus	Roach	Mid to lower	-
Salmo trutta	Brown trout	Mid to upper	-
Decapod crustacea			
Euastacus woiwuru	Central highlands spiny cray	Upper reaches	C
Euastacus yarraensis	Southern Victorian spiny cray	Upper reaches	C

C – Common

River blackfish (*Gadopsis marmoratus*) have been recorded in the upper part of the catchment between Mt Evelyn and Kalorama. This species inhabits a variety of stream types, preferably with abundant cover such as snags and aquatic vegetation (Jackson *et al.* 1996). Water depths greater than 10 cm for juvenile blackfish, greater than 20 cm for adult blackfish, and water velocities less than 20 cm s^{-1} for adults and juveniles are preferred (Koehn *et al.* 1994). River blackfish are considered susceptible to increased sediment loads in streams (Doeg and Koehn 1994).

Mountain galaxias (*Galaxias olidus*) have been recorded in the mid to upper catchment between Lilydale and Olinda. This species typically inhabits small streams at higher elevations where water temperatures remain cool in summer (McDowall and Fulton 1996).

Two migratory freshwater species have been recorded in Olinda Creek. Short-finned eel (*Anguilla australis*) are present throughout most of the catchment and occupy a variety of habitats including rivers, creeks and wetlands (Beumer 1996). Common galaxias (*Galaxias maculatus*) have recently been recorded in the lower part of the catchment near Lilydale Airfield, Coldstream (*personal observation*). This species typically inhabits slow flowing or still waters (Koehn and O'Connor 1990). Common galaxias and short-finned eel are known to migrate between the freshwater and estuarine sections of river systems at some stage in their life cycle. Fish passage requirements of these migratory species comprise two life stages and hence fish sizes (adult and juvenile), with the life history stages of these species migrating at different times of the year (Koehn and O'Connor 1990, O'Connor and Koehn 1998).

In the past Dight's Falls represented a major barrier to the upstream movement of native migratory fish throughout the Yarra River catchment. It is likely that recolonisation of Olinda Creek by common galaxias has been facilitated by the construction of a fishway at Dight's Falls in 1994. The occurrence of short-finned eel throughout the catchment is not unexpected because this species can bypass instream barriers by either climbing over or moving around them. An additional six species may recolonise Olinda Creek as a result of the Dight's Falls fishway being installed (Table 3-2), including one species, the Australian grayling (*Prototroctes maraena*), which is considered vulnerable in Victoria and is listed on the Victorian *Flora and Fauna Guarantee Act* 1988.

Table 3-2. Native fish species that have the potential to recolonise the Olinda Creek catchment, including their conservation status (DNRE 2000d).

Scientific Name	Common Name	Conservation Status
Galaxias truttaceus	Spotted galaxias	C
Galaxias brevipinnis	Broad-finned galaxias	C
Geotria australis	Pouched lamprey	C
Mordacia mordax	Short-headed lamprey	C
Prototroctes maraena	Australian grayling	V, FFG
Pseudaphritis urvilli	Tupong	C

Abbreviations denote conservation status as: V – Vulnerable, C – Common, FFG indicates that the species is listed on the Victorian *Flora and Fauna Guarantee Act* 1988.

The above six migratory species (Table 3-2) have been recorded in recent surveys of other Yarra River tributaries (Zampatti and Raadik 1997, Lieschke and Raadik 1999, Raadik *et al.* 1999, Koster and Raadik 2000). Their apparent absence from Olinda Creek may be attributable to a number of factors including habitat conditions, unknown instream barriers and limited survey effort. Lilydale Lake, in the mid part of the catchment would represent a barrier to any further upstream migration of these species. Stream gauging station 229609 at York Road, Mount Evelyn, would also impede fish movement.

3.2 Aquatic Macroinvertebrates

Macroinvertebrate assemblages in the headwaters of Olinda Creek are diverse yet population densities tend to be moderate to low (Enright *et al.* 1980; Jones and Ferdinands 1993, Pettigrove and Hall 1999). In contrast, species richness tends to decrease and population densities increase with increasing distance downstream from the headwaters (Enright *et al.* 1980, Jones and Ferdinands 1993, Pettigrove and Hall 1999). In the mid and lower reaches, herbivorous and detrital feeders including aquatic snails (Enright *et al.* 1980), oligochaetes (aquatic worms) and chironomids (non-biting midges) (Jones and Ferdinands 1993) dominate aquatic macroinvertebrate populations. Jones and Ferdinands (1993) suggest that intact catchment vegetation and minimal changes to flow regimes are major factors for retaining a diverse community structure in the upper reaches. AUSRIVAS[1] scores are ‘below reference’ at Mt. Evelyn (0.82) and ‘well below reference’ at Coldstream (0.54) indicating that macroinvertebrate populations in Olinda Creek are generally less diverse than expected (Bessell-Browne 2000). SIGNAL[2] scores indicate macroinvertebrate populations tend to be dominated by families highly sensitive to pollution in the upper catchment (SIGNAL score at Mt Evelyn - 6.38) and that families more tolerant to pollution become more abundant with increasing distance downstream (SIGNAL score at Coldstream - 5.27) (Bessell-Browne 2000).

With regards to threatened macroinvertebrates, the Dandenong freshwater amphipod (*Austrogammarus australis*) has been recorded in the Olinda Creek catchment (Papas *et al.* 1999). This species is classified as insufficiently known in Victoria (DCNR 1995) and is listed on the Victorian *Flora and Fauna Guarantee Act* 1988.

3.3 Reptiles and Amphibians

Approximately 22 species of reptile and 11 species of amphibian have been recorded in the Olinda Creek catchment. Three of these species are considered threatened in Victoria; the warty bell frog (*Litoria raniformis*) and swamp skink (*Egernia coventryi*), both classified as vulnerable, and the lace monitor (*Varanus varius*), classified as 'data deficient' (DNRE 2000d). The warty

[1] AUSRIVAS (Australian Rivers Assessment System) is a predictive model used to assess river health. The model predicts families of macroinvertebrates which should occur at a particular sites and compares the probabilities of these predicted families with the number of families actually found.
[2] SIGNAL is a biotic index which uses sensitivity (tolerance or intolerance) of aquatic invertebrate families to pollutants

bell frog inhabits vegetation within or in the vicinity of permanent water while the swamp skink occurs in low-lying marshes and swamps amongst sedge and heath habitat (Cogger 2000). The lace monitor does not directly depend on the riparian environment, although such areas often provide the only remaining suitable habitat. Very few records of these species exist in the catchment.

3.4 Other Vertebrates

Approximately 179 species of bird (168 native and 11 exotic) and 37 species of mammal (31 native and seven exotic) have been recorded in the Olinda Creek catchment (DNRE 2000b). A number of the native species are considered threatened in Victoria, including one critically endangered, seven endangered and nine vulnerable species. There are also ten species listed on the Victorian *Flora and Fauna Guarantee Act* 1998 (DNRE 2000). A number of the threatened bird species are listed on international treaties one of which, the regent honeyeater (*Xanthomyza phrygia*), is listed as critically endangered on the Australian and New Zealand Environment and Conservation Council *List of Threatened Australian Vertebrate Fauna* (DNRE 2000d).

In addition to two terrestrial mammal species (Table 3-3), platypus (*Ornithorhynchus anatinus*) also occur in Olinda Creek and rely directly on the instream environment for shelter and food. Although platypus are reasonably abundant upstream of Lilydale Lake, they are encountered infrequently in lower reaches of the catchment downstream of Lilydale (Pettigrove and Hall 1999).

3.5 Instream and Riparian Flora

Approximately 280 species of instream and riparian flora (254 native and 26 exotic) have been recorded in the Olinda Creek catchment, of which four species are considered threatened in Victoria (Gullan *et al.* 1990, DNRE 2000c). The swamp bush pea (*Pultanaea weindorferi*) is classified as rare, the tussock sedge (*Carex iynx*) and Yarra gum (*Eucalyptus yarraensis*) are both classified as poorly known, and the Buxton Gum (*Eucalyptus crenulata*) is classified as endangered (DNRE 2000c). The swamp bush pea and Yarra gum are also classified as rare in Australia, and the Buxton Gum is classified as endangered in Australia (Gullan *et al.* 1990).

Table 3-3. Threatened bird and mammal species previously recorded from the Olinda Creek catchment, including their conservation status (DNRE 2000d).

Scientific name	Common name	Conservation status
Birds		
Anas rhynchotis	Australasian shoveler	V
Adrea alba	Great egret	E, FFG, c, j
Aythya australis	Hardhead	V
Biziura lobata	Musk duck	V
Botaurus poiciloptilus	Australasian bittern	E
Chlidonias hybridus	Whiskered tern	LR
Coturnix ypsilophora	Brown quail	D
Haliaeetus leucogaster	White-bellied sea-eagle	E, FFG, c
Lichnenostomus melanops cassidix	Helmeted honeyeater	E, FFG
Ninox strenua	Powerful owl	E, FFG
Nycticorax caledonicus	Nankeen night heron	V
Oxyura australis	Blue-billed duck	V
Platalea regia	Royal spoonbill	V
Plegadis falcinellus	Glossy ibis	V, c
Pomatostomus temporalis	Grey-crowned babbler	E, FFG
Rallus pectoralis	Lewin's rail	E
Porzana pusilla	Baillon's crake	V
Strictonetta naevosa	Freckled duck	E, FFG
Tyto tenebricosa	Sooty owl	V, FFG
Xanthomyza phrygia	Regent honeyeater	CE, FFG
Mammals		
Dasyurus maculatus	Spot-tailed quoll	E, FFG
Mastacomys fuscus	Broad-toothed rat	LR

CE – Critically Endangered, E – Endangered, V – Vulnerable, LR – Lower Risk near threatened, D – Data deficient, FFG – species listed on Victorian *Flora and Fauna Guarantee Act* 1988, c – species listed on China Australia Migratory Bird Agreement, j – species listed on Japan Australia Migratory Bird Agreement.

4. HYDROLOGY OF THE OLINDA CREEK CATCHMENT

4.1 Flow Regime

Flow records are available from two gauging stations within the Olinda Creek catchment (Table 4-1). Mean annual rainfall in the catchment is approximately 1000 mm (Rowan 1982) and streamflow in Olinda Creek has been previously described as seasonal. Low flow months have been identified as January through to May and high flows occur from August through to November (Doeg 1999). A review of historical flow data from both gauging stations on Olinda Creek (Table 4-1) show similar trends in seasonal flow (Fig. 4-1 & 4-2). At gauging station 229609, median flow over the low flow period (January to May) ranges from 10.2 – 18.3 ML.day^{-1}. Over the high flow period (August and November) median flow is approximately 16.8 – 27.1 ML.day^{-1}. Gauging station 229602 is located lower in the catchment below Lilydale Lake and historical records show that flow exhibits slightly greater seasonality here than at Mt Evelyn (Fig. 4-2). Over the low flow period, median flows are approximately 8.1-21.9 ML.day^{-1} with minimum median flows occurring in March. Higher flows occur between June and November and range between 21.4 and 51.4 ML.day^{-1} with maximum median flows recorded in September. Urban developments have also affected the flow regime of Olinda Creek, increasing the area of impervious surfaces leading to increased volume of run-off and size of the flood peak from rainfall events (Richards 1999, Walsh and Breen 1999). Substantial discharges from Lilydale Purification Plant, downstream of Lilydale, contribute to environmental flows during dry periods (Pettigrove and Hall 1999).

Table 4-1. Location of gauging stations on Olinda Creek and their period of record.

Gauge	Location	Period of Record
229609	York Rd. Mt Evelyn	January 1987 – July 1999
229602	Beresford Rd. Lilydale	July 1987 – December 1998

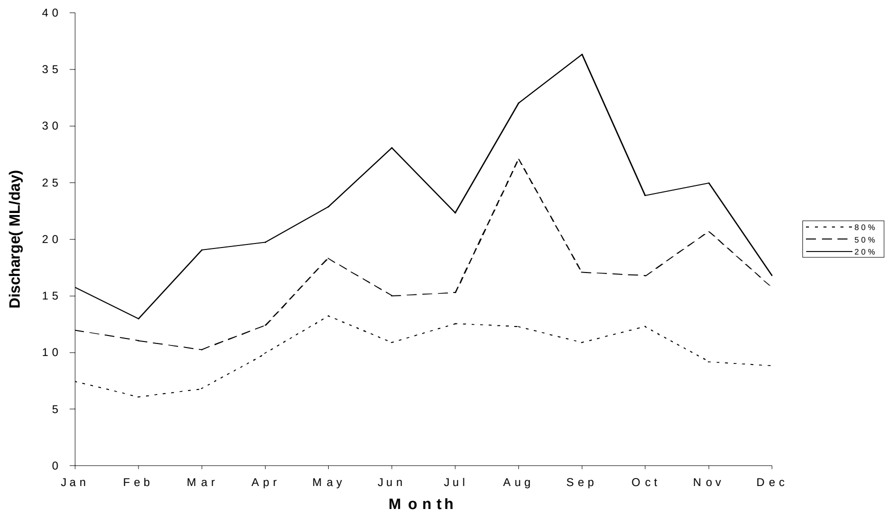

Figure 4-1. 80th, 50th and 20th percentile exceedence flows recorded at the Mt Evelyn gauging station (229609).

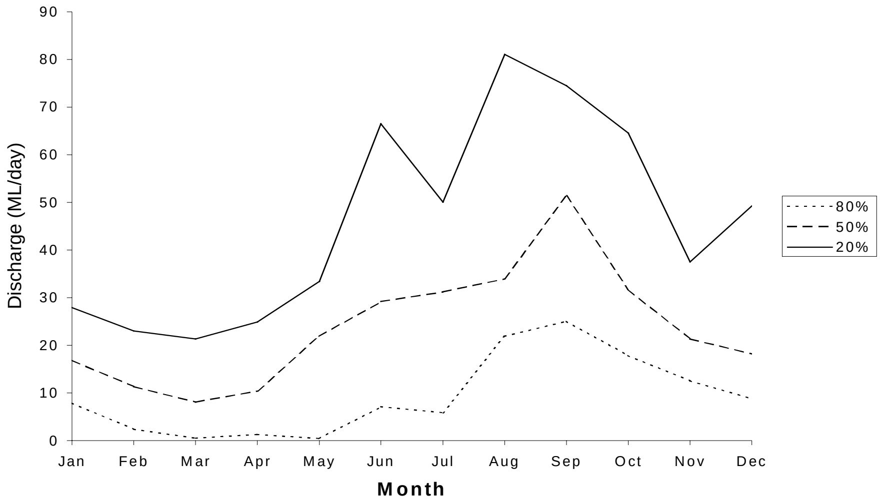

Figure 4-2. 80th, 50th and 20th percentile exceedence flows recorded at Beresford Road gauging station (229602).

4.2 System Management

Both surface water and groundwater harvesting occurs in the Olinda Creek catchment for commercial and domestic and stock use (Richards 1999) and Melbourne Water and Southern Rural Water manage these extractions respectively. There are currently 67 licensed diversion permits in the Olinda Creek catchment which includes Lyre Bird Gully Creek, Rich Creek and Wishing Well Creek sub-catchments (Table 4-2). The total volume of water licensed for diversion within this area is 747 $ML.yr^{-1}$ (Melbourne Water unpublished data, Doeg 1999). Sixty-nine percent of licensed diversions are above Lilydale Lake. The majority of licensed diversions are for irrigation and represent approximately 70 % (503 $ML.yr^{-1}$) of the total licensed volume for the catchment. Data from Pettigrove and Hall (1999) (Table 4-3) indicate that approximately 58 % of licensed water diversion is for use on market gardens with the other major uses being for industrial, other irrigation, and domestic and stock. Under the *Water Act 1989*, a person has a statutory right to take and use water from a waterway for that persons domestic and stock use (as defined in the Water Act) free of charge and without a licence if the waterway is on land the person occupies, or if the person occupies land immediately adjacent to the waterway ie. no crown land reserve between the persons land and the waterway. There is no available information on how many landholders exercise this right or how much water is diverted (Haydon 1994). The volume of water diverted from Olinda Creek over the summer months ranges from 3.5-4.1 $ML.d^{-1}$. During the winter when there is less demand for irrigation, diversion volumes reduce to between 0.7-1.6 $ML.d^{-1}$.

Table 4-2. Entitlement details for licensed water diversion from Olinda Creek and it tributaries[*] (from Melbourne Water unpublished data, Doeg 1999).

License	Number		Licensed Volume
	Olinda Creek	Tributaries	($ML.yr^{-1}$)
Irrigation	26	4	503
Stock and domestic	15	6	42
Stock, domestic and Commercial	5	4	37
Commercial	1	-	5
Off-stream dams	3		79
On-stream dams	-	3	26
Industrial	2	-	55
Totals	**50**	**17**	**747**

*, includes entitlements for licensed water abstraction from the Lyre Bird Gully Creek, Rich Creek and Wishing Well Creek sub-catchments.

Table 4-3. The number of diversion permits, major landuse and licensed volumes of water available for diversion in Olinda Creek (After Pettigrove and Hall 1999).

Major Activity	No. Permits	Licensed Volume ($ML.yr^{-1}$)
Industrial	3	67
Pasture	3	75
Orchard	2	15
Vineyard	2	16
Nursery	9	52
Market gardens	20	453
Domestic and stock	25	68
Other	3	24
Total	**67**	**770***

*, note that total licensed volume presented by Pettigrove and Hall (1999) varies from the 747 $ML.yr^{-1}$ presented in this study.

During excessively dry spells when stream discharges drop to critical levels (as measured in the Yarra River at Warrandyte), Melbourne water may implement a *Drought Response Plan* which places restrictions on water use.

There are two main water storages within the Olinda Creek catchment. Lilydale Lake is essentially a transparent storage (inflows equal outflows; Steve Nicol 2001 Melbourne Water *pers. comm.*) and was constructed by Melbourne Water in 1988 for non-consumptive water use (recreational) and to mitigate against flooding of low lying areas downstream of this point. Lilydale Lake has a low flow bypass mechanism (Steve Nicol 2001 Melbourne Water *pers. comm.*). Silvan Reservoir is located adjacent to the upper reaches of Olinda Creek and does not receive any water harvested from the Olinda Creek catchment. A minimum environmental flow of $2ML.day^{-1}$ is released from Silvan Reservoir (Pettigrove and Hall 1999).

4.3 Alterations to Natural Flow Regime

The flow regime of Olinda Creek has been altered by diversion of water for a variety of uses (see section 4-2 above). This is especially true over the low flow period (January – May) and in the upper reaches of the catchment, upstream of Lilydale Lake, from which approximately 70% of the total licensed water extraction occurs. A comparison of derived natural flows (Melbourne Water unpublished data, Doeg 1999)[3], mean passing flows, minimum passing flows and diversion at a monitoring site at Mt Evelyn (Lilydale Lake)[4] are presented in Figure 4-3. Over the low flow period the magnitude of mean passing flows have decreased by approximately 20-30% from the derived natural flows (Fig. 4-3). The difference between derived natural flows and mean passing flow is much less over the high flow season when there is less demand for water diversion. Minimum passing flows at Mt Evelyn range from approximately 1 to 5 $ML.day^{-1}$. Over the same period, licensed water diversion may range from 3.5 to 4.1 $ML.day^{-1}$ in Olinda Creek (Melbourne Water unpublished data, Doeg 1999).

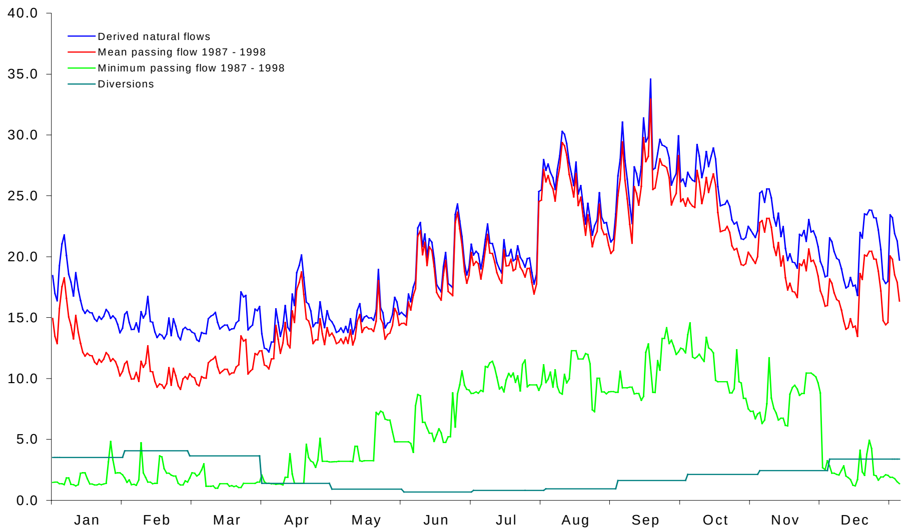

Figure 4-3. Gauged and modelled daily flows and mean daily diversions for each month for Olinda Creek at the Mt Evelyn monitoring site.

4.4 Water Quality

Relatively few water quality data are available for Olinda Creek compared with other locations in the Yarra catchment (Pettigrove and Hall 1999). Water quality surveys have been conducted along Olinda Creek by Sharples (1994), Walsh and Breen (1999) and Melbourne Water (Melbourne Water Corporation 1997, Melbourne Water unpublished data). The results of these studies generally indicate a large increase in nutrients and suspended solids in Olinda Creek downstream of Lilydale. The Lilydale Purification Plant is regarded as a major source of nutrients to Olinda Creek with substantial additional inputs from other drains in the lower reaches

[3] Natural flows were derived by Theiss and represent gauged passing flows plus diversions plus a demand factor (Steven Nicol, Melbourne Water *pers. comm*)
[4] Calculated for the period 1987-1998.

of the catchment (Pettigrove and Hall 1999). The increase in suspended solids lower in the catchment is most probably due to bank erosion and resuspension of sediments in the mid to upper reaches during flushes and periods of high flow (Pettigrove and Hall 1999). The Lilydale Purification Plant contributes only a small amount of suspended solids to Olinda Creek.

Dissolved oxygen concentrations decline in the lower reaches of Olinda Creek (Walsh and Breen 1999), although levels do comply with State environment protection policy objectives (EPA 1997). High levels of nutrients discharged from Lilydale Purification Plant support substantial microbial respiration which may contribute to depleted oxygen levels in the lower reaches of Olinda Creek (Pettigrove and Hall 1999). Recent upgrading of the plant is expected to lead to improvement in water quality in Olinda Creek (Pettigrove and Hall 1999).

Pettigrove and Hall (1999) assessed the level of various toxicants throughout the catchment. Heavy metals were below ANZECC/ARMCANZ (1999) interim sediment quality guidelines (ISQG) at most sites. Lead and zinc exceeded the ISQG-high downstream of Lilydale at Nelson Road. Nickel slightly exceeded the ISQG-low at Silvan Reservoir outfall. Chlorpyrifos and polycyclic aromatic hydrocarbons were not detected.

Water quality data from monthly spot measurements of Olinda Creek at McIntyre Lane, Coldstream, between May 1999 and June 2000 was sourced from Melbourne Water (Melbourne Water unpublished data) (Appendix 1). Water temperature is generally above 20°C over the summer period between December and March. Over the winter months (June to August) water temperature can decrease to around 10 °C. Dissolved oxygen concentrations remain reasonably stable (6-8 $mg.L^{-1}$) for most of the year, although they peak during the high flow months (July and August) at approximately 14 $mg.L^{-1}$. pH values vary little with season yet fluctuate between approximately 6.5 and 7.5 between months. Electrical conductivity is highest (approximately 550-610 $\mu S.cm^{-1}$) over the summer period between November and March and lowest (275-500 $\mu S.cm^{-1}$) over the higher flow months between April and October. Suspended solids are relatively constant throughout the year, except for an increase in April and June which are presumably correlated to high flow events. Similarly, turbidity is relatively constant throughout the year, except for an increase in January, April and June.

5. METHODOLOGY FOR ENVIRONMENTAL FLOW STUDIES

The Olinda Creek SMP is primarily concerned with the summer low flow period when the majority of stream diversions occur. Nevertheless, the recommendations provided facilitate sustainable flow and management of water allocation throughout the year.

The technique employed in the present study was based on an adaptation of the instream flow incremental method (IFIM) (Bovee 1982) together with a multiple transect method, historical flows and expert knowledge to recommend environmental flows. These recommendations aim to protect the environmental values present in the Olinda Creek catchment and also meet the objectives of the Olinda Creek SMP.

The IFIM technique relates changes in depth and velocity to the availability of fish habitat and has commonly been used in Victoria to aid in the determination of environmental flows (Tunbridge and Glenane 1988, Hall 1989). The application of this technique requires a sound knowledge of the flow and habitat requirements of the fish species of concern, particularly depth and velocity. In order to determine habitat availability for native fish species in Olinda Creek, river blackfish were selected as key species. River blackfish are the deepest bodied native fish species found in the Olinda Creek system and it is assumed that providing a suitable amount of potential habitat for river blackfish will also provide habitat for smaller native species, invertebrates and aquatic vegetation in the Olinda Creek system.

The depth and velocity requirements of river blackfish have been derived from a study by Koehn *et al.* (1994) on the habitat preferences of this species in Armstrong Creek, a tributary of the upper Yarra River. The habitat requirements of river blackfish were divided into two life stages, juveniles (fish < 150 mm in length) and adults (fish > 150 mm in length) (Table 5-1).

Table 5-1. Depth and velocity requirements of river blackfish.

Species	Life Stage	Depth (m)	Velocity (m/s)
River blackfish	Juvenile	>0.1	<0.2
	Adult	>0.2	<0.2

Unlike previous Victorian studies (Tunbridge and Glenane 1988, Hall 1989), we have not divided habitat requirements into rearing, resting, passage and spawning requirements as the available data for the depth and velocity requirements of river blackfish is not comprehensive enough to enable the modelling of habitat availability with regards to all requirements. The habitat requirements we have used encompass both rearing and resting activities. This habitat covers the largest component of stream area and is considered the most important habitat over the low flow period.

As a tool to aid in the determination of environmental flow regimes, fish habitat availability may be compared under natural and modified flow regimes and an arbitrary decision made on a specified level of fish habitat to maintain. However, the particular amount of habitat required is the subject of considerable conjecture (Pusey 1998). In order to refine our recommendations, a multiple transect analysis was used in addition to the IFIM method. This technique examines the relationship between wetted area and stream discharge to determine minimum environmental flows. We have used wetted useable area which is defined as that area that is greater than 0.02 m deep.

In the current study we have examined the relationship between stream discharge and wetted useable area and blackfish habitat preferences in an attempt to maintain habitat availability similar to that which may occur naturally. These relationships have been examined in conjunction with an assessment of historical and modelled natural flows in Olinda Creek (Melbourne Water unpublished data, Doeg 1999).

5.1 Field Measurements of Hydraulic Parameters and Habitat

Three sites were selected in the Olinda Creek system to establish reaches where habitat availability could be measured at a range of flows (Figure 2-1). The sites were located on the upper, middle and lower reaches of Olinda Creek, thus providing detailed information on discharge and habitat availability throughout the catchment.

At each flow site a series of transects was established in areas of habitat that were representative of that particular reach of river. The number of transects was determined by the number required to provide a representative sample of all habitat types and associated hydrological characteristics. Transects were placed perpendicular to the thalweg (from bank to bank), each end being identified by a permanent marker to facilitate future measurements at a range of flow conditions. A measuring tape was extended across the stream and, depending on the width and uniformity of the stream, velocity (m/s), depth (m) and substrate type were measured at 0.1 to 0.5 m intervals. Depth was measured to the nearest 0.01 m using a 1 m steel ruler and velocity was measured using a Hydrological Services OSS PC-1 current meter with a CMC 20 digital counter.

Table 5-2. Environmental flow study sites in Olinda Creek catchment.

Site No.	Location	Grid Reference (map no., zone, coordinates)	Altitude (masl)*
S1	upstream of bridge on Road 19, off Olinda Creek Road, Kalorama	7922 55 357300 5812200	240
S2	upstream of bridge on York Road, Mt. Evelyn	7922 55 355500 5815700	140
S3	downstream of bridge on McIntyre Lane, Coldstream	7922 55 355700 5826200	80

*, masl denotes "metres above sea level"

5.2 Modelling Using RHABSIM

The amount of total wetted useable habitat (depths greater than 0.02 m) and habitat potentially available to juvenile and adult river blackfish, at a range of flows, was calculated using the RHABSIM hydraulic and habitat simulation system (Payne and Associates 1994). Criteria curves were constructed for adult and juvenile river blackfish. The habitat preferences for these species were not weighted (Mathur *et al.* 1985). Instead, a binary approach was used and habitat was classified as being present or absent. When combined with the hydraulic characteristics of the stream section this approach predicts how much habitat (user defined) will be potentially available to a particular species. It is important to note that predictions made with RHABSIM do not suggest that system productivity will be altered through changes in habitat availability.

Changes in habitat availability at a range of flows were measured in the field rather than by hydraulic simulation. Due to an absence of accurate stage/discharge data for most sites in the Olinda Creek system, it was considered impractical to calibrate a hydraulic simulation model of the stream sections. In addition, the structural complexity (woody debris, aquatic vegetation etc.) of the stream reaches, may have resulted in inaccurate hydraulic calibration of a model (Gordon *et al*. 1992, Courot 1989).

5.3 Water Quality

Spot measurements of basic water quality parameters, dissolved oxygen, electrical conductivity, temperature and pH were recorded at each site at a range of flows. Water temperature (ºC) and electrical conductivity ($\mu S.cm^{-1}$ @ 25 ºC) were measured with a WTW LF 320 meter, dissolved oxygen ($mg.L^{-1}$) with a WTW OXI 320 meter and pH with a WTW pH 320 meter. All instruments were calibrated according to manufacture's specifications.

6. Results and Observations

6.1 Site Descriptions

Site 1. Olinda Creek downstream of Olinda Creek Road, Kalorama

Site 1 (Figure 2-1 & 6-1) was located in the upper part of the catchment near Kalorama. The creek is bordered by the Dandenong Ranges National Park on its south-eastern side and private property on its north-western side. The riparian zone is relatively intact and comprised predominantly of native species. Both the overstorey and understorey vegetation is dense and typical of wet sclerophyll forest. The average width of the stream is two metres and the flow type is predominantly riffle and run (80% of stream area), with smaller sections of glide and rapid/cascade. Substrate was predominantly cobble (50%) and pebble (15%) in riffle areas, and silt/clay (30%) in glide and run reaches. Instream cover comprised overhanging vegetation (30%), branches (20%), leaf litter (10%) and logs (2%). Impacts on the environmental values of the site include exotic plant species, a stream ford, culvert and small weir, and the removal of surrounding vegetation.

Figure 6-1. Olinda Creek downstream of Olinda Creek Road, Kalorama

Site 2. Olinda Creek at York Road, Mount Evelyn

Site 2 (Figure 2-1 and 6-2) was located in the middle reaches of the catchment near Mt Evelyn. The creek is bordered by a public reserve on its southern side and private property on its northern side. The riparian zone is highly disturbed, comprising a narrow but dense stand of native and exotic species. The overstorey vegetation consists almost entirely of exotic willow and sparse stands of eucalypt, wattle and tea tree. Understorey vegetation comprised dense stands of exotic creepers and blackberry. The average width of the stream channel is 3 m and undercutting of banks, erosion and siltation were evident. Flow type was predominantly run (80% of stream area), with smaller sections of glide (10%) and pool (10%). Substrate type was predominantly silt (70%), with smaller areas of clay (20%) and sand (10%). Instream cover comprised branches (60%), leaf litter (20%), overhanging bank and streamside vegetation (15%) and logs (5%). Impacts on the environmental values of the site include a gauging station, exotic plant species, urban rubbish and the removal of riparian vegetation.

Figure 6-2. Olinda Creek at York Road, Mount Evelyn

Site 3. Olinda Creek downstream of McIntyre Road at Lilydale Airfield

Site 3 (Figure 2-1 and 6-3) was located in the lower reaches of the catchment near Coldstream. The stream is bordered by grazing land on its western side and the Lilydale airfield on its eastern side. The riparian zone is extremely disturbed, comprising a narrow strip dominated by exotic species (willow, blackberry and grasses) with some native species (wattle and tea tree) also present. The average width of the stream is 3 m and bank incision, bank slumping and erosion were evident. Flow type is predominantly glide (60%) and run (30%), with a small area of riffle (10%). Substrate is predominantly clay (80%), with smaller areas of silt (15%) and fine sand (5%). Instream cover consisted of overhanging vegetation (10%), bank overhang (5%) and logs (2%). Impacts on the environmental values of the site include extensive clearing of riparian vegetation, exotic plant species, urban rubbish, water diversion and channelisation.

Figure 6-3. Olinda Creek downstream of McIntyre Road at Lilydale Airfield

6.2 Summary of Stream Condition and Flow Related Issues

In general, the condition of waterways (bed stability, bank stability, aquatic structure and shade) and riparian vegetation (bank vegetation, verge vegetation and pest/noxious plants) throughout the Olinda/Stringybark catchment is regarded as moderate to poor (Chesterfield and Sovitslis 1994). Stream bed siltation is evident along the entire length of Olinda Creek, stream bed degradation occurs in some sections, and weed infestations occur throughout most of the catchment (ID&A 1999).

Assessment of stream condition based on the Index of Stream Condition (ISC) indicates environmental condition is best upstream of Mt Evelyn township (ID&A 1999). The riparian vegetation of Olinda Creek upstream of Mt Evelyn is relatively intact, consisting of dry sclerophyll forest dominated by messmate and narrow-leaf peppermint eucalypts, wet gullies of tree ferns, manna gum, mountain grey gum, and swamp gum communities (Richards 1999). Nevertheless, along some sections of the creek the understorey is heavily infested by exotic creepers, blackberry and other weed species which are inhibiting the regeneration of native species. Instream habitat conditions are relatively good, particularly near the headwaters. There is a diverse range of instream cover present, including logs, branch piles, boulders and overhanging vegetation. There is some accumulation of silt within the creek which may affect habitat conditions by reducing habitat diversity, but overall this section of creek is considered to have high value for aquatic fauna.

Downstream of Mt. Evelyn to Lilydale, riparian vegetation is highly disturbed. A continuous indigenous riparian zone is present (ID&A 1999), although exotic grasses, creepers, blackberry and willow are widespread and abundant. Instream habitat conditions are reasonable. Instream cover such as branches and leaves is abundant, although moderate aggradation of the streambed, bank undercutting and erosion also occur. Downstream of Lilydale to the Yarra River confluence, riparian vegetation is extremely degraded, consisting almost entirely of exotic willows, blackberry and other weed species. Instream habitat conditions are relatively poor. Instream cover is scarce and largely restricted to overhanging exotic vegetation. Stream channelisation is extensive, and moderate streambed aggradation, bank incision, slumping and erosion also occur. Cattle access to the stream has accelerated bank erosion (ID&A 1999).

6.3 Habitat Availability

Three parameters have been used to examine the relationship between available habitat and discharge over the summer low flow period namely, wetted useable area and, juvenile and adult blackfish habitat criteria. Reach length and number of transects varied between sites depending on the hydraulic and geomorphological complexity and habitat diversity (Table 6-1). The number of transects established at each site ranged from 17 to 19. Habitat availability was measured at each site during three flows of different magnitude (Table 6-2).

Table 6-1. Details of habitat survey reaches and multiple transects

Site	Reach length* (m)	No. Transects	Average Distance between transects (m)
S1 - Kalorama	39.9	17	2.3
S2 – Mt Evelyn	82.1	17	4.8
S3 - Lilydale	76.1	19	4.0

*, thalweg length

Table 6-2. Habitat availability at three sites in Olinda Creek at three discharges

Site	Discharge ($ML.d^{-1}$)		Habitat Availability**		
	Site	Mt Evelyn*	Wetted useable area (≥0.02m)	Juvenile Blackfish	Adult Blackfish
Site 1	2.1	2.2	59.9	21.4	8.9
Kalorama	7.4	26	82.2	28.7	15.1
	14.3	36	90.6	37.7	21.2
Site 2	5.8	2.4	237.5	222.5	195.6
Mt. Evelyn.	17.4	17.0	264.4	220.4	193.8
	20.0	26.0	271.2	234.7	218.7
Site 3	14.9	2.2	163.8	113.9	93.8
Lilydale	25.6	11.0	206	106.7	93.4
	65.5	21.0	250.1	89.8	79.2

*, telemeted reading at gauging station 229609 provided by Melbourne Water
**, for blackfish habitat criteria see section 5.

At site 1 (Kalorama), wetted useable area (depths ≥ 0.02 m) decreased by approximately 30% when stream discharge decreased from 14.3 to approximately 2 $ML.day^{-1}$. The habitat potentially available to juvenile and adult blackfish also decreased by approximately 50% (Fig. 6-4).

In contrast, wetted useable area and the area potentially available to juvenile and adult blackfish at site 2 (Mt Evelyn) varied little with flow. A decrease in discharge from 26 to 2.4 $ML.day^{-1}$ resulted in wetted useable area and the potential area available to juvenile and adult blackish decreasing by approximately 5 to 13% (Fig. 6-5). Site 2 is predominantly a deep run which retains habitat even at low flow.

The relationship between discharge and wetted useable area measured at site 3 (Lilydale) is similar to site 1. A decrease in discharge from 65.5 to 14.9 $ML.day^{-1}$ decreases wetted useable area by approximately 35%. Nevertheless, the area of habitat potentially available to juvenile and adult blackfish actually increases by 22 and 16% respectively as discharge decreases over this range (Fig. 6-6).

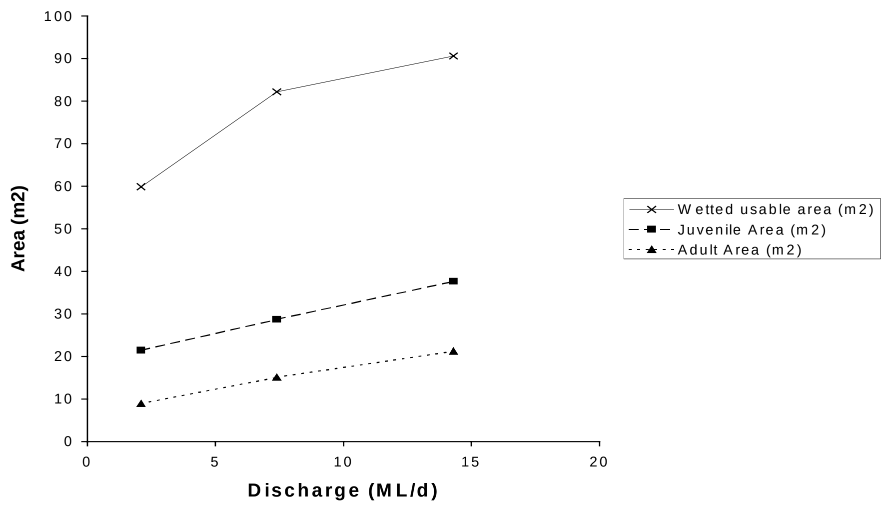

Figure 6-4. Habitat availability at a range of flows at Site 1 (Kalorama). Wetted area is that area with depths ≥ 0.02 m. Depth and velocity parameters for juvenile and adult blackfish habitat at discussed in section 5.

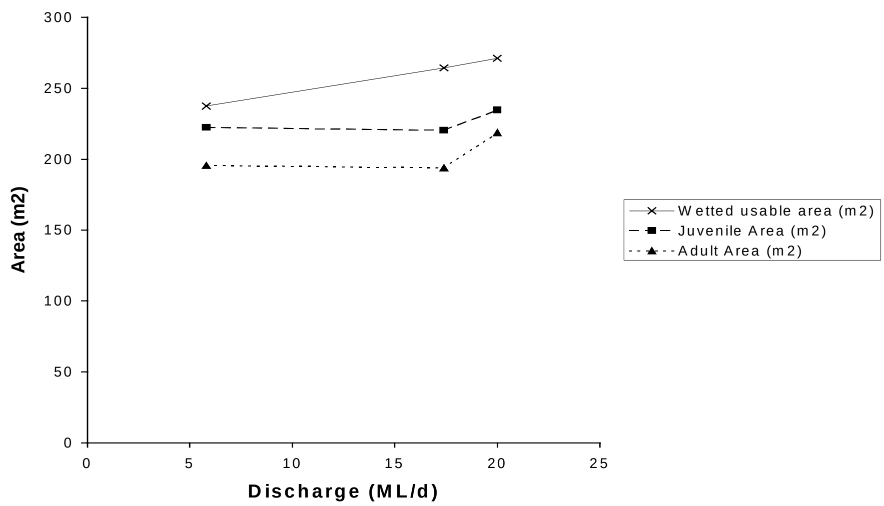

Figure 6-5. Habitat availability at a range of flows at Site 2 (Mt Evelyn). Wetted area is that area with depths ≥ 0.02 m. Depth and velocity parameters for juvenile and adult blackfish habitat at discussed in section 5.

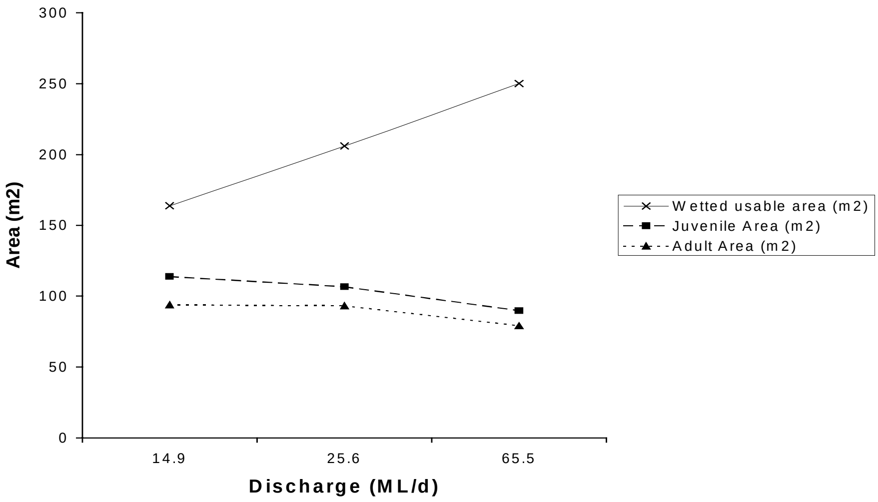

Figure 6-6. Habitat availability at a range of flows at Site 3 (Lilydale). Wetted area is that area with depths ≥ 0.02 m. Depth and velocity parameters for juvenile and adult blackfish habitat at discussed in section 5.

6.4 Water Quality

Spot measurements of basic water quality parameters were recorded at each site on each occasion when habitat surveys were undertaken. The relationships between discharge and, water temperature, electrical conductivity, dissolved oxygen, turbidity and pH are shown in Table 6-3. Water temperature was highest during the summer low flow months at all sites and ranged from 14.1 °C at site 1 (Kalorama) to 17.6 °C at the most downstream site (site 3, Lilydale). Lower water temperatures were recorded during higher flow winter months and ranged from 8.4 °C to 9.1 °C. Electrical conductivity varied slightly with flow. At Site 1 and 2 electrical conductivity tended to increase slightly as discharge decreased. In contrast, electrical conductivity at site 3 (Lilydale) was higher at low flows compared to higher flows. Dissolved oxygen and pH remained stable at all sites for the three flow events. Turbidity was variable and displayed no apparent trend to seasonal flows. Fluctuations in turbidity reported here are probably a result of flushes and spates around the time of measurement.

Table 6-3. Measurements of water quality parameters at three sites on Olinda Creek at a range of discharges

Site	*Discharge ML.day^{-1}	Date	Water Temperature (°C)	Electrical Conductivity (µS.cm^{-1})	Dissolved Oxygen (mg.L^{-1})	Turbidity (NTU)	pH
S1	3.25	28/3/00	14.1	60	10.0	28.3	6.1
Kalorama	12.5	02/6/00	9.10	121.0	10.1	17.4	7.1
	26.4	07/6/00	10.0	122.8	9.8	32.8	6.7
S2	3.25	29/3/00	14.5	78.5	10.1	10.7	6.3
Mt Evelyn	10.7	19/7/00	8.4	84.8	10.7	48.1	6.2
	12.5	02/6/00	10.2	146.8	9.6	19.5	7.1
S3	3.25	30/3/00	17.6	502.0	8.7	8.6	7.8
Lilydale	7.2		*	*	*	*	*
	10.0	31/7/00	11.2	263.0	9.7	56.6	7.2

*, as measured at gauging station 229609 (York Rd. Mt Evelyn)

7. ENVIRONMENTAL FLOW RECOMMENDATIONS

7.1 Environmental Flow Management Objectives

The following management objectives apply specifically to the management of stream flow in Olinda Creek.

1. *Maintain appropriate minimum environmental flows over the low flow period.*

2. *Provide appropriate flushing flows and high flow regimes that provide suitable conditions for migration and spawning of native fish species and essential geophysical processes such as channel scouring and silt removal.*

3. *Maintain water quality in accordance with SEPP (Waters of Victoria) – Schedule F7 Waters of the Yarra Catchment (EPA 1999), including provision of summer flushing flows.*

4. *Ensure that winter-fill diversions are set at a level that does not impact on essential biological and geomorphological processes.*

In addition, several management objectives specifically apply to biodiversity conservation.

1. *Maintain and/or restore diversity and complexity of instream habitat (e.g. woody debris).*

2. *Maintain and/or enhance diversity of aquatic fauna species and encourage recolonization of Olinda Creek by migratory species.*

3. *Provide unimpeded fish access throughout the Olinda Creek system through removal of instream barriers.*

7.2 Summer Low Flow Period

Minimum environmental flows are recommended for Olinda Creek based on an assessment of historical flow data (natural and current regimes), fish habitat availability and expert opinion. These recommendations aim to meet the environmental management objectives listed above. The precautionary principle (i.e. a suitable ecological safety margin) has been applied due to our limited knowledge of the relationship between flow regimes and the ecology of native freshwater fish in Olinda Creek.

Minimum environmental flows are recommended for each site at which habitat surveys were undertaken (Table 7-1). As approximately 70% of licensed diversions are located above Lilydale Lake and, as derived natural flows are available for the Mt Evelyn gauging station (229609) these site specific recommendations are referenced to the Mt Evelyn gauge. A minimum environmental flow is therefore recommended for Mt Evelyn gauge (229609) which should meet the environmental management objectives (listed above) for each site. During periods of very low flow, the minimum environmental flow recommendation or natural flow, which ever is least, should be applied.

Table 7-1. Minimum environmental flow recommendations for three sites on Olinda Creek.

Site location	Environmental Flow ($ML.day^{-1}$)
Site 1 Olinda Creek at Kalorama	2
Site 2 Olinda Creek at Mt Evelyn*	**6**
Site 3 Olinda Creek at Lilydale	15

*, compliance point

In most instances, the recommended environmental flow is the same, or close to the lowest stream discharged measured during the fish habitat surveys. The relationship between habitat availability and stream discharge cannot be extrapolated beyond the lowest measured point on the habitat availability curves (see section 6).

Further more, discrepancies in measurements of stream discharge at the Mt Evelyn gauge (229609) between, telemeted readings, measurements calculated from the stage-discharge relationships and the discharge measurements we took exist (Table 7-2). For the purposes of this study, we have used the telemeted readings as they correlate most closely with our estimates.

Table 7-2. Estimates of stream discharge at Mt Evelyn gauging station (gauge 229609) from stage-discharge relationships, telemetered estimates and discharge transect estimates.

Date	(Stage Height) and **Discharge** $ML.d^{-1}$	Telemeted Discharge $ML.d^{-1}$	Discharge Transect Estimate $ML.d^{-1}$
29/03/00	(0.14) **3.25**	2.4	5.8
20/07/00	(0.20) **10.17**	17.0	17.4
02/06/00	(0.21) **12.5**	26	24
28/03/00	(0.14) **3.25**	2.2	5.7
02/06/00	(0.21) **12.5**	26	24.5
07/06/00	(0.27) 26.4	36	36.6
30/03/00	(0.14) **3.25**	2.2	not taken
08/08/00	(0.18)	-	11.3
31/07/00	(0.2) 10.7	21.0	17.0

Consequently, the recommendation of a minimum environmental flow is difficult. As a result, the precautionary principle has been employed and flows substantially lower than the lowest discharge measured at each site have not been recommended. Nevertheless, the recommended flows are similar to the natural flows that may be expected during the lowest flow events if no diversion occurred. Summer flushing flows should also be maintained with the aim of alleviating potential water quality deterioration during the summer low flow months.

7.3 Winter Fill Diversions

Diversion of water during high flow periods (winter-fill) has the potential to alleviate environmental stress due to water abstraction during low flow periods. It is important to recognise however the importance of flushing flows and high flow regimes to maintaining essential biological and geomorphological processes.

Many native freshwater fish species require specific seasonal flow events, especially within the higher flow months of June to November to stimulate or facilitate life history processes such as spawning and spawning migrations. Since the construction of Dight's Falls fishway it is likely that some species reliant on seasonal high flows will recolonise lower reaches of Olinda Creek (below Lilydale Lake). Although no migratory species were recorded in the system in a survey conducted in 1999 (Hannon *et al.* 1999), during the course of our habitat availability surveys, we observed common galaxias (*G. maculatus*) at site 3 (Lilydale). Other species such as Australian grayling and tupong also have the potential to recolonise. Further more, flushing flows and high flows over the same period are essential for stream forming processes such as channel scouring and sediment removal. The magnitude and variability of flows to preserve processes such as these are difficult to quantify and cannot be quantified using fish habitat availability. Nevertheless, a precautionary approach that preserves important components of the high flow regime may be used.

Rules for winter-fill volumes and rates are currently being developed as a component of a sustainable diversion limits project being undertaken by the Department of Natural Resources and Environment. Recommendations that are developed through this project can be applied to the Olinda Creek system when completed.

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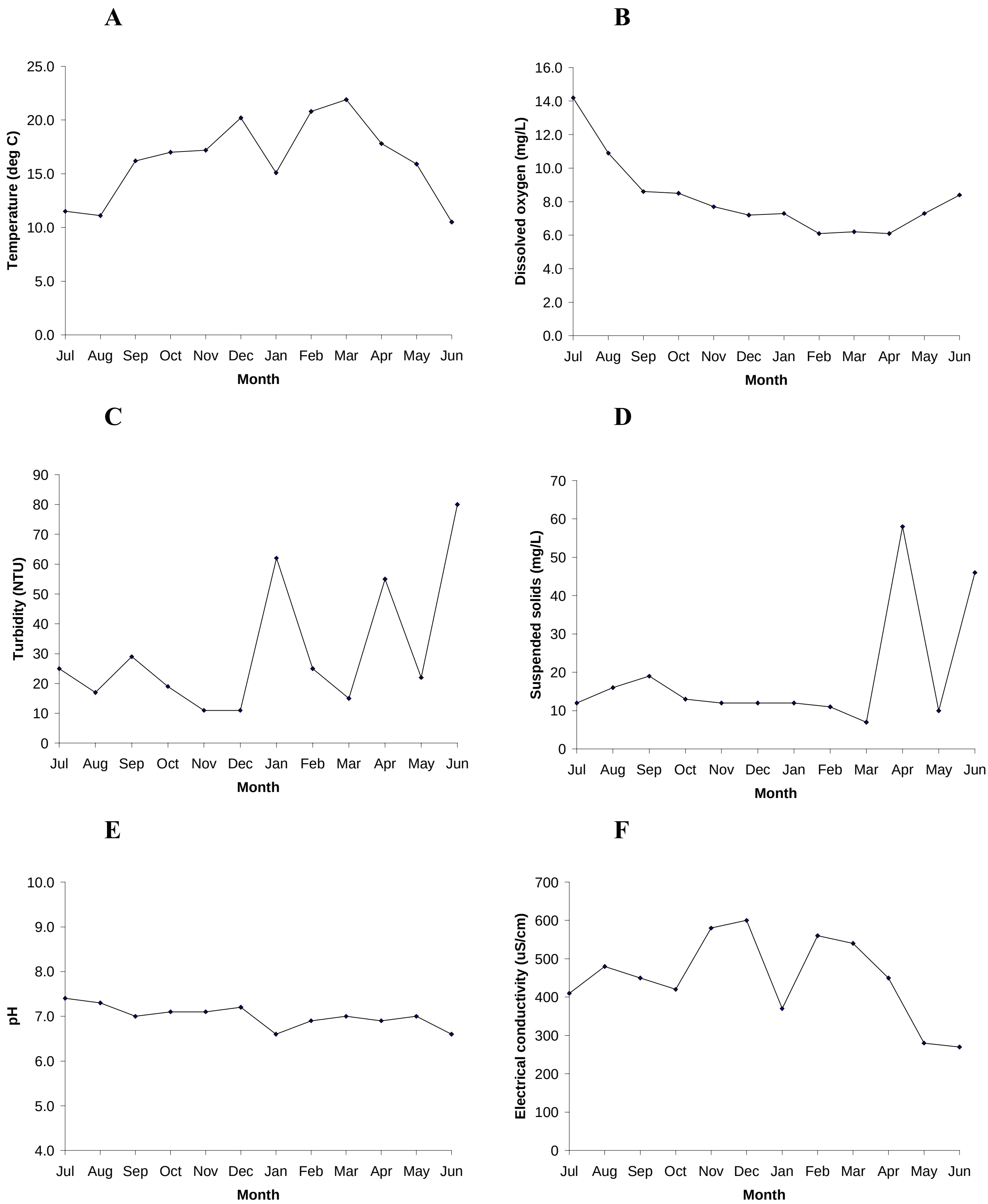
10. Appendix 1. Water Quality

10.1 Seasonal Variation in Water Quality



Monthly spot measurements at McIntyre Lane (near coldstream) of basic water quality parameters: A – temperature; B – dissolved oxygen; C – turbidity; D – suspended solids; E – pH and F – electrical conductivity over the period of study from July 1999 to June 2000. Data from Melbourne Water (2000)