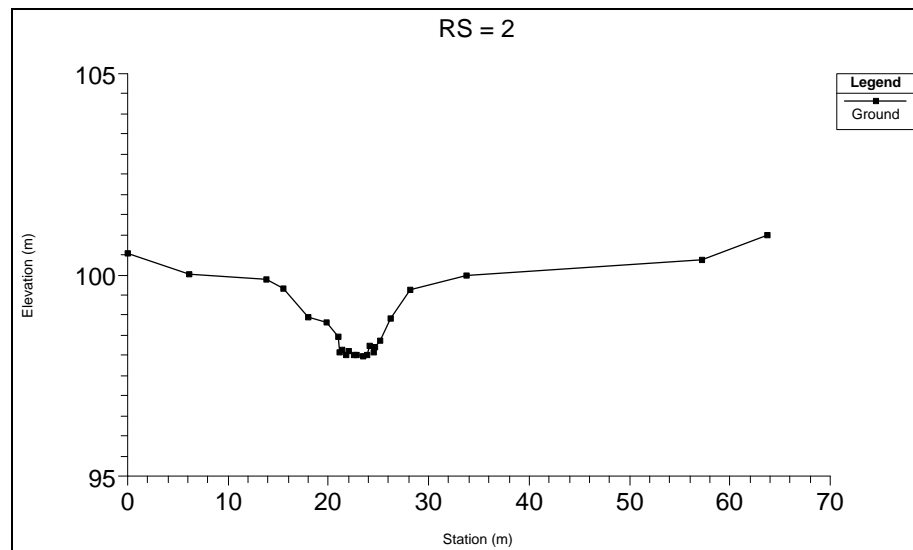


Environmental Flow Determination For The Little Yarra And Don Rivers



Final Recommendations

Prepared by

**The Little Yarra and Don Rivers Environmental Flow
Technical Panel (LYDEFTP)**

August 2004

The Little Yarra and Don Rivers Environmental Flow Technical Panel

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Acknowledgements

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Abbreviations used in this report

EVC	Ecological Vegetation Class
FLWS	Standardised Statewide Method For Determining Environmental Water Requirements in Victoria
LWD	Large Woody Debris
LYDEFTP	Little Yarra and Don Rivers Environmental Flow Technical Panel
ML	Megalitres (1,000,000 litres)
ML/d	Megalitres per day
MWC	Melbourne Water Corporation
SDL	Sustainable Diversion Limit
SFMP	Stream Flow Management Plans
SKM	Sinclair Knight Merz

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Cover Photo: HEC RAS output showing cross section from the Don River.

Summary

Flow Recommendations for the Little Yarra River

Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
T	Low Flow Season					T	High Flow Season				
Cease to Divert Flow: 35 ML/d											
						High Flow Fresh: 200 ML/d, 7 per year, 2 days					
						High Flow Fresh: 500 ML/d, 1 year in 2, 2 days					
Bankfull and Overbank Flow: 750 ML/d, 1 year in 7, 1 day											

Flow Recommendations for the Don River

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T	Low Flow Season				T	High Flow Season					
Cease to Divert Flow: 3 ML/d					Cease to Divert Flow: 10 ML/d						
Low Flow Fresh: 10 ML/d, 3 per year, 9 days					High Flow Fresh: 45 ML/d, 2 per year, 1 day						
					High Flow Fresh: 80 ML/d, 1 in 3 years, 1 day						
Bankfull and Overbank Flow: 100 ML/d, 1 in 5 years, 1 day											

Contents

<i>The Little Yarra and Don Rivers Environmental Flow Technical Panel</i>	ii
<i>Acknowledgements</i>	ii
<i>Abbreviations used in this report</i>	ii
SUMMARY	III
1. INTRODUCTION	5
THE LITTLE YARRA AND DON RIVERS CATCHMENTS.....	5
1.2 OUTLINE OF THIS REPORT.....	7
2. METHODS USED TO DETERMINE FLOW RECOMMENDATIONS	8
2.1 THE FLOWS METHOD (STAGE 1).....	8
2.2 THE FLOWS METHOD (STAGE 2).....	9
<i>Representative Sites</i>	9
<i>Surveys of selected reaches</i>	10
<i>Hydraulic Modelling</i>	10
<i>Formulation of Recommendations</i>	11
3. ENVIRONMENTAL OBJECTIVES AND FLOW REQUIREMENTS	14
3.1 ENVIRONMENTAL OBJECTIVES.....	14
3.2 FLOW REQUIREMENTS AND ASSESSMENT CRITERIA.....	14
4. ENVIRONMENTAL FLOW RECOMMENDATIONS	16
4.1 THE LITTLE YARRA RIVER.....	16
<i>Flow Recommendations</i>	16
<i>Summary Table for the Little Yarra River</i>	24
<i>Achievement Table for the Little Yarra River</i>	24
<i>Supporting Recommendations</i>	25
4.2 THE DON RIVER.....	27
<i>Flow Recommendations</i>	27
<i>Summary Tables</i>	35
<i>Achievement Tables</i>	35
<i>Supporting Recommendations</i>	36
5. REFERENCES	38
APPENDIX 1 PROFILES AND TRANSECTS IN THE LITTLE YARRA RIVER	39
APPENDIX 2. PROFILES AND TRANSECTS IN THE DON RIVER	43

1. Introduction

Melbourne Water Corporation is currently in the process of developing Stream Flow Management Plans (SFMP) for the Little Yarra and Don Rivers, two unregulated tributaries of the Yarra River system. SFMPs aim to ensure the long term sustainability of river system health by reaching a balance between environmental requirements and consumptive uses of water.

The main aim of the SFMP process is to devise rules related to water sharing in the catchment, part of which is to provide water for environmental uses. However, without an understanding of the environmental water requirements of each catchment, defensible and equitable decisions on water allocation between consumptive and environmental uses cannot be made.

This **Final Recommendations Report** presents environmental flow recommendations for the Little Yarra and Don Rivers. Background information for this report, detailed study site descriptions and environmental objectives for the two rivers have previously been described in detail in the **Issues Paper** (LYDEFTP, 2004). It is important that the Final Recommendations be read in conjunction with the information contained in the Issues Paper.

Environmental flow recommendations were determined for the Little Yarra and Don Rivers using the FLOWS method. FLOWS is the standardised Statewide Method For Determining Environmental Water Requirements in Victoria (SKM *et al.*, 2002). FLOWS was specifically developed to be used for environmental components of SFMPs, and so is the most appropriate method for this project.

The Little Yarra and Don Rivers catchments

The study area for this project covers the catchment of the Little Yarra River to its confluence with the Yarra River near Launching Place, and the Don River to its confluence with the Yarra River near Launching Place (Figure 1.1).

The Little Yarra River rises to the east of Powelltown in the Yarra Ranges. The stream flows generally north-west through the townships of Powelltown, Three Bridges, Gladysdale, and Yarra Junction, before joining the Yarra River near Don Road in Launching Place. The total catchment area of the Little Yarra River is approximately 154 km².

The Don River rises near Panton Gap on Mt Toole-Be-Wong. The river flows south and joins the Yarra River near Don Road in Launching Place. The Don River catchment is approximately 22 km².

Both river systems drain areas of high and reliable rainfall (1000-1400 mm per annum), and both streams maintain permanent flows throughout the year.

The Little Yarra River and the Don River are characterised by steep forested upper catchments on public land and partially cleared freehold land on the lower slopes and river flats. While both upper catchments have been subject to some timber harvesting in the past, the upper section of the Don River catchment is now protected from resource use within the boundaries of Yarra Ranges National Park. The upper section of the Little Yarra River catchment is State Forest and timber harvesting is ongoing.

As a consequence of the moderate to steep slope gradients, a large proportion of both catchments is not suitable for agriculture and remains in a comparatively unmodified condition. Only 13% of the Don catchment and 23% of the Little Yarra catchment have been cleared.

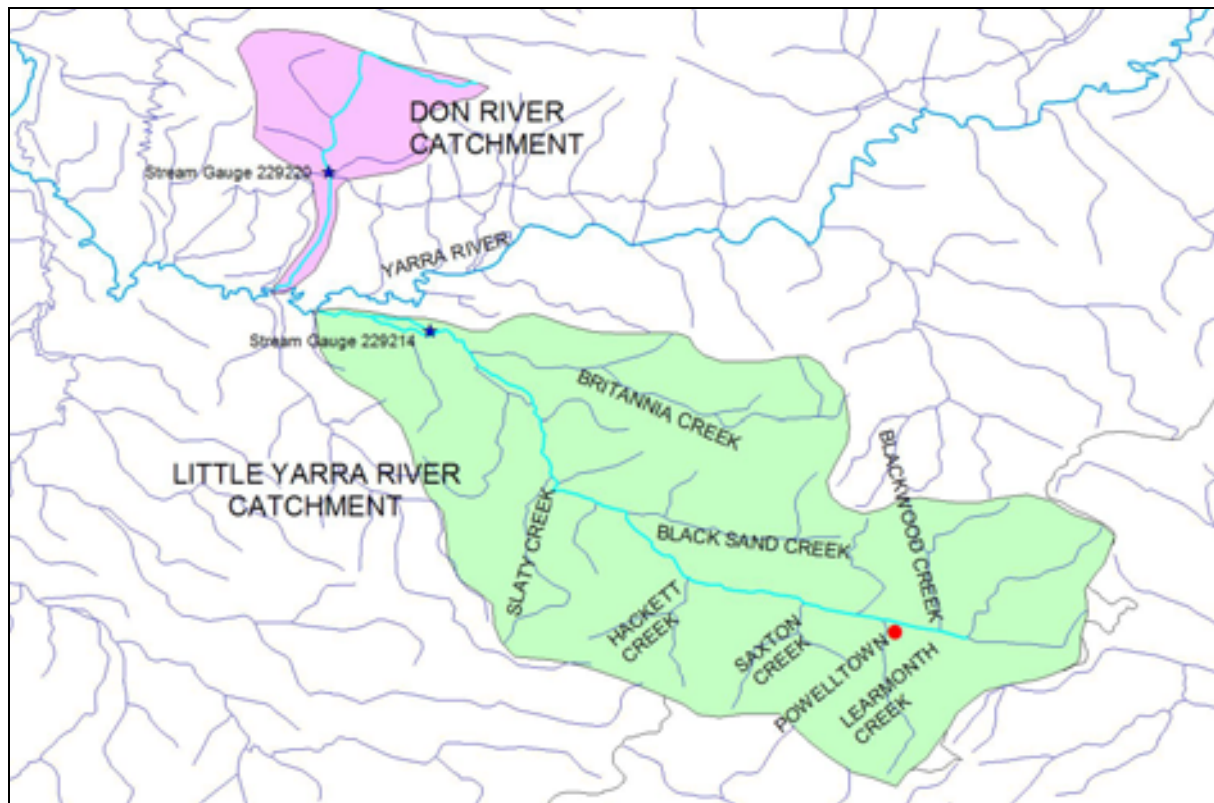


Figure 1.1. Map of the study area.

The dominant geological substrate within the Little Yarra River catchment is granite, characterised by free-draining somewhat sandy soils, and springs and soaks emerging from prominent breaks in the slope gradients. The bed of the river is also dominated by sandy substrates. The catchment has significant ground water resources, contributing an estimated 73% of the streamflow in the Little Yarra River (SKM, 2004).

The Don River drains a comparatively small, south facing catchment falling from the Mount Donna Buang Range. Erosion resistant rhyodacite (acid volcanic rocks) has resulted in steep terrain. The bed of the stream tends to be dominated by rocky substrates (boulders, cobbles, pebbles and gravel).

The uncleared upper regions of both catchments are characterised by the predominance of tall Eucalypt forests with Riparian Forest¹ along the larger watercourses. Here both rivers are confined to narrow valleys with little or no valley development.

Environmental flow recommendations are not required for these uncleared forested reaches upstream of Powelltown on the Little Yarra River, or for the forested reaches of the Don River upstream of the Don Road crossing. Thus, these forested upstream areas of each catchment are not included in this study.

Clearing for intensive agriculture has taken place where slope gradients are moderate to low in the middle and lower reaches of both rivers. The cleared areas of both valleys are closely settled, commonly with small holdings and “hobby farms”.

¹ In Victoria, the principal unit for vegetation description and mapping for land use planning and management is the Ecological Vegetation Class (EVC). EVC’s, such as Riparian Forest, represent aggregations of floristic communities with structural, physiognomic and floristic affinities that exist under a common regime of ecological processes within a particular environment.

In the Little Yarra catchment, there is a relatively narrow strip of cleared land along the river between Powelltown and the inflow of the Black Sand Creek. Below Black Sand Creek, the wider valley is mostly cleared for a variety of agricultural uses, including orchards, vineyards, vegetables, tree farms and grazing.

The lower section of the Don River valley has also been cleared for a variety of agricultural uses (similar to those in the Little Yarra catchment).

Both catchments are unregulated – they do not have any major irrigation or urban water supply reservoirs located on the rivers.

1.2 Outline of this Report

Section 2 of this report presents an outline of the FLOWS method used in this project.

A summary of the environmental objectives for the Little Yarra and Don Rivers, the flow regime and components required to meet these objectives are presented in Section 3.

The flow recommendations for each river are then presented in Section 4 in a standard format with three individual sections:

- The flow recommendations to achieve the ecological objectives, with justifications;
- Summary tables of the recommendations;
- Summary table on whether the recommendations are being met by current flow or diversion management; and
- Supporting recommendations (non-flow related issues that require attention in order that the flow recommendations will achieve their intended objectives).

2. Methods used to Determine Flow Recommendations

2.1 The FLOWS method (Stage 1)

The recommendations for environmental flows in the Little Yarra and Don Rivers have been developed using the standardised Statewide Method For Determining Environmental Water Requirements in Victoria, referred to as the FLOWS method (SKM *et al.*, 2002). The major steps in the FLOWS method are shown in Figure 2.1.

Environmental flow recommendations are established in two stages. Stage 1 involves the collection of available data on ecology and hydrology of the study area, a field assessment of the catchments, and the selection of study sites, all leading to the development of environmental objectives for the two rivers (the desired future condition of environmental assets) and Environmental Flow Requirements (the types of flows required to meet environmental objectives).

The description of available data, the field assessment, the representative sites, the Environmental Objectives and the flow requirements are detailed in the **Issues Paper** (LYDEFTP, 2004).

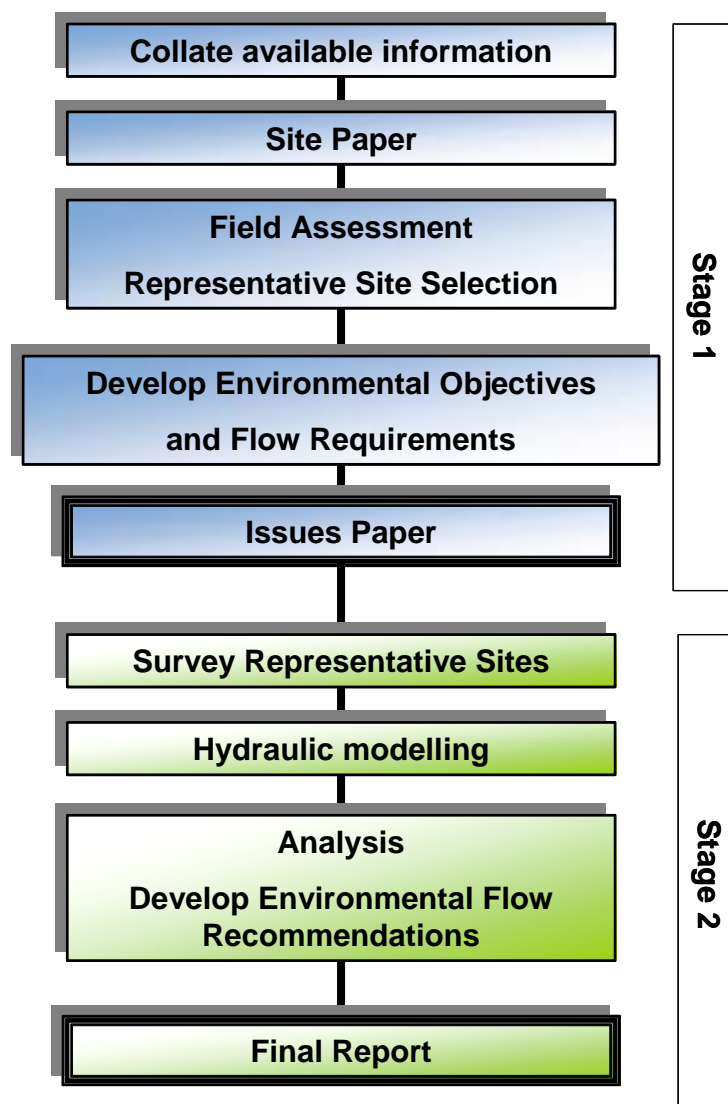


Figure 2.1. Outline of the steps in the FLOWS method.

2.2 The FLOWS Method (Stage 2)

Representative Sites

Two representative sites were selected in the Little Yarra and Don Rivers for further study (Table 2.1). This section further describes the rationale for the selection of these sites.

Table 2.1. Representative sites chosen during Stage 1 for more detailed assessment.

Site	Location	ESMAP reference
Little Yarra River	Behind the Caulfield Grammar School camp	685 A13
Don River	Upstream of the entrance to Toolebewang Farm	684 F8

The Little Yarra River

For the purposes of this study, the Little Yarra in the study area (downstream of Powelltown) was divided into two reaches, with the boundary between the reaches at the inflow of Britannia Creek. Upstream of Britannia Creek, the river flows in the Little Yarra River valley proper. The river channel is relatively consistent throughout this reach. The bed is dominated by sand (due to the local granite geology), and bed features are determined by local flow conditions and the presence of in-stream objects (rocks and woody debris). Deeper areas are located on the outside of bends, and downstream of objects (mainly woody debris) in the channel. The remainder of the bed has a relatively constant depth, with variability determined by localised flow paths. Small benches and bars formed within the channel are common.

Downstream of Britannia Creek, the river channel is larger and more sinuous (but has been straightened in some sections), as the river flows across the Yarra River floodplain.

The Representative Site on the Little Yarra River was chosen as typical of the upstream reach (Powelltown to Britannia Creek). Sites downstream of Britannia Creek were rejected as representative sites, due to the potential influence of the Yarra River on the channel form.

It was considered that a single site would be satisfactory for environmental flow assessments. The river from Powelltown to Britannia Creek had a consistent form, so that recommendations made at a single site should be directly proportional to other sites in the valley.

The site immediately behind the Caulfield Grammar School camp was selected, as it is the most downstream accessible site examined. Detailed survey work had also been conducted in the area for other Melbourne Water projects (including the reinstatement of large woody debris).

The Don River

The Don River in the study area (i.e. downstream of the major forested area) can be described as three separate reaches. In the upstream reach (from the Don Road crossing to around Ewerts Road), the slope of the channel is very steep, with the river flowing in a narrow valley. There is no defined floodplain, although some of the steep valley slopes have been cleared for agriculture. The river consists mainly of pools separated by steep cascades flowing over a boulder dominated bed.

In the middle reach (Ewerts Road to downstream of Dalry Road), the river flows through the Don River valley proper, with the floodplain characteristics resulting exclusively from Don River flows. The grade of the river here is still relatively steep for a lowland section. Consequently, the river channel consists mainly of long runs, and short sections of steep riffles, both with a rock-cobble bed. There were few sections of deeper areas, formed on bends and behind obstructions.

In the lower reach, downstream of Dalry Road to the Yarra River, the river flows across the valley floor of the Yarra River floodplain.

The Representative Site on the Don River was chosen as typical of the Don River valley proper (the mid reach). The steep upstream section was not selected for further study as few diversion licences are located in that section. The flows therefore would be close to natural for most of the time. With few tributaries, it was concluded that environmental flow recommendations made downstream (and their management) would offer adequate protection for these upstream reaches.

A site was not chosen on the Yarra River floodplain. The channel form there would, in part, be derived from the higher Yarra River flows, and lower grade, which meant flow recommendations based in this reach would not be representative of upstream reaches that form the focus of the Stream Flow Management Plan.

Surveys of selected reaches

Cross-sectional surveys at the Don River site (Table 2.1) was undertaken by Paul Crowe Pty Ltd Survey Group. Transects identified during the Stage 1 field inspection were surveyed using a Total Station. Cross-sections were taken perpendicular to the flow, and survey points focused on the channel detail and near channel features (such as benches), with fewer points on the floodplain.



In the Little Yarra River, cross-sections had been surveyed as part of another Melbourne Water Corporation project monitoring the impacts of re-instating woody debris into the river (R. Coleman and A. Russo, MWC, pers. comm.). The level of detail provided by these transects was considered suitable for this study.

Profiles and cross sections from the Little Yarra and Don Rivers are shown in Appendices 1 and 2.

Hydraulic Modelling

Hydraulic modelling of the sites was undertaken using the one-dimensional steady state backwater analysis model HEC RAS. The survey data provides the geometric input, with Manning's n (a measure of channel roughness) being the most important interpretive component of the hydraulic modelling. The appropriate Manning's n for each part of each cross-section was identified through observations of the reach during the field inspection, and identification of reach variability from photographs (with calibration to a known water surface elevation not possible due to gauge locations).

Normal depth was used as the downstream boundary condition, with a slope determined by a combination of the water surface level and the channel invert level, particularly in the lower reaches. The use of this boundary condition allows for adjustment of flows without a corresponding adjustment of boundary condition.

The key output from the modelling is a graphic presentation of each transect (Figure 2.2, top). 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).

Long profiles can also be displayed, showing the maximum depth at each surveyed transect at different flows (Figure 2.2, bottom).

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 for fish passage flows (as specified in the Issues Paper and later analysis).

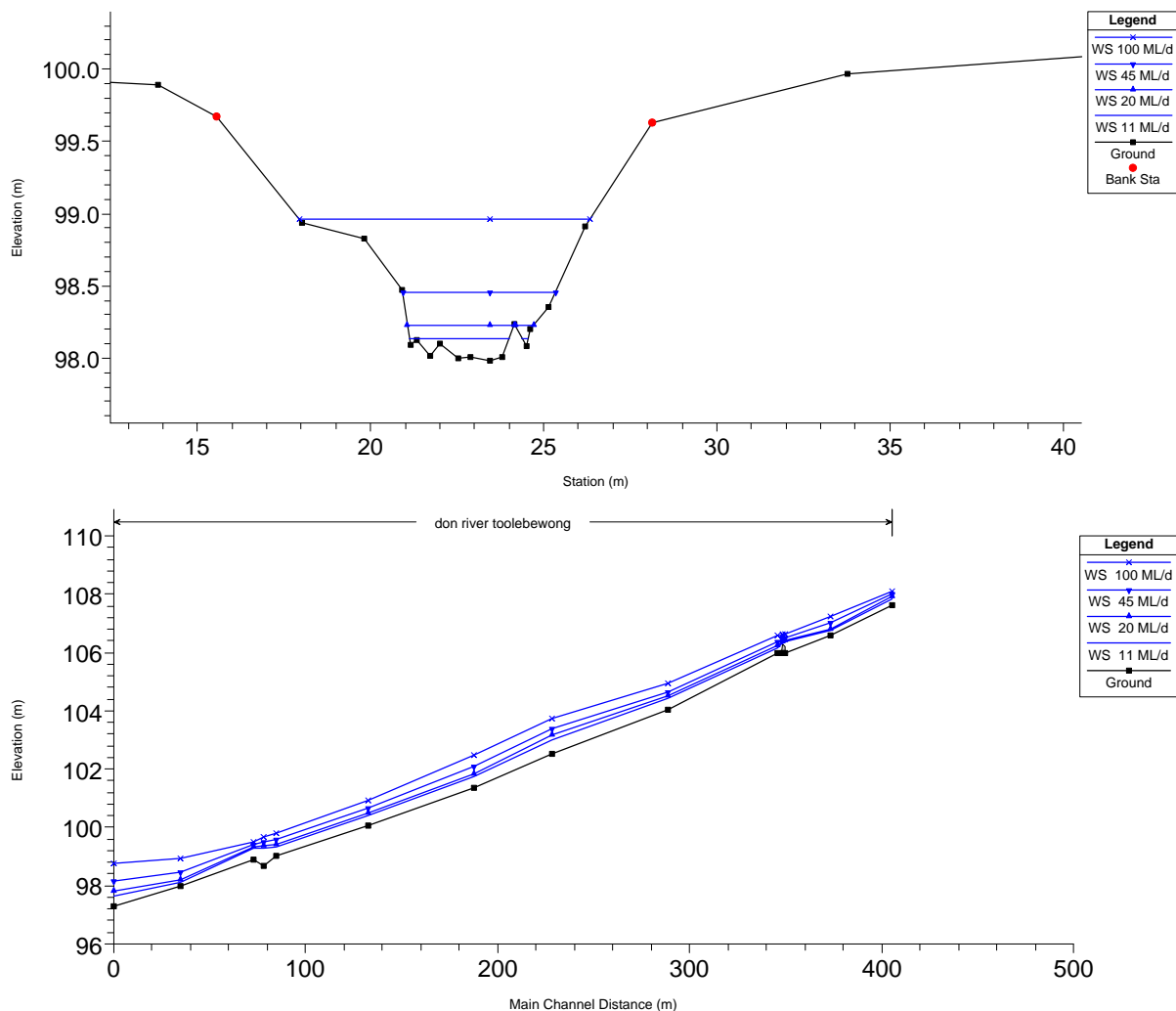


Figure 2.2 Example cross-section (top) and long profile (bottom) outputs from the hydraulic model in the Don River at 4 different flows (11, 20, 45 and 100 ML/d).

Formulation of Recommendations

Final environmental flow recommendations for the Little Yarra and Don Rivers reaches were prepared at a workshop held at the Arthur Rylah Institute for Environmental Research, Heidelberg, on 19th August 2004.

Recommendations for Flow rate

For each Representative Site (Table 2.1), the surveyed transects and long profiles were examined to identify key features (pools, shallow areas, in-channel benches and banks) that could be used to assess environmental flows, based on the objectives, environmental flow requirements, flow-related processes and criteria developed in the Issues paper.

Each flow component (Table 2.2) was considered in turn. If a particular flow component was associated with an Environmental Flow Requirement for the site, a suitable flow recommendation was derived by the Technical Panel using a number of analysis tools. These included:

- Criteria or definitions for each of the flow components, either from the FLOWS method or developed by the Technical Panel;
- The hydraulic model developed for each reach;
- Drawings and notes taken during the field inspection; and
- Photos taken during the field inspection, and those taken of each transect during the survey.

Where a feature of the surveyed transects or profile was identified, a series of increasing flows were run through the model, until a particular flow satisfied the criterion for the particular objective. In general, the lowest flow required to achieve the criterion was selected as the recommendation for that flow component and that objective.

Environmental flow recommendations were also based on both the season in which the component should occur in order to achieve the objective. The seasonality of the flow regime in the Little Yarra and Don Rivers was determined in the Issues Paper, based on the distribution of flows throughout the year (Table 2.3).

Table 2.2. Flow components and definitions used in environmental flow determinations

Flow component	General Description
Cease-to-flow	No discernible flow in the river, or no measurable flow recorded at a gauge.
Low Flows	Flow that generally provides a continuous flow through the channel, primarily during the Low Flow Season (see Table 2.3)
Low Flow Freshes	Small and short duration peak flow events that exceed the baseflow and last for at least several days during the Low Flow Season.
High Baseflow *	Persistent increases in the seasonal baseflow that remain within the channel, primarily during the High Flow Season (see Table 2.3)
High Flow Freshes	Small and short duration peak flow events that exceed the baseflow and last for at least several days during the High Flow Season.
Bankfull flow	Flows that completely fill the channel, with no spilling onto the floodplain
Overbank flows	Flows greater than bankfull that result in surface flow on floodplain habitats

* - referred to as “High Flow” in the Flows Method

Table 2.3. Seasonality of flows adopted for the Little Yarra River and Don Rivers.

Season	Little Yarra River	Don River
Low Flow Season	January – May	February – May
Transitional: Low to High	June	June – July
High Flow Season	July – November	August – December
Transitional: High to Low	December	January

Recommendations for Frequency and duration

Recommendations also include a frequency and duration for a number of flow components (Low and High Flow Freshes, Bankfull, and Overbank Flows). For these, the frequency per year and the duration were based on the natural flow regime for that season.

Once a particular flow rate was established for the recommendation, the natural flow regime for the appropriate season was subjected to a spell analysis, determining the frequency and duration of flows that exceed the recommended flows under natural condition. The frequency and duration recommendation was generally based on the median frequency per year, and the median duration of each event over the period of record.

It needs to be realised that the recommendations for frequency and duration are not “fixed” requirements. Recommendations for frequency and duration are modified with an “or natural” qualification. This means that for the measurement of compliance, if the natural flows in any one year provide less events than the recommended value, then only the natural number need to be present in

the flow regime. If the natural flows result in more than the recommended value, then only the recommended value need to be present (i.e. additional flows can be harvested).

For example, if a recommendation states that 7 flows above the recommended value need to occur and only 2 actually occur in any year, then if 2 are provided, the flows can be seen to be in compliance with the recommendation. If 10 flows occur naturally, then only 7 need to be present in the post-diversion regime for the flows to be in compliance with the recommendation.

Similarly, for the duration recommendation, if a natural flow shorter than the recommendation occurs, then as long as the flow event is not reduced in duration by diversions, the flow is in compliance with the recommendation. A flow longer than the recommended duration can be reduced by diversions, but only to the length of the recommendation.

Recommendations for Independence

It can be argued that the function of a particular flow event (its role in achieving a particular objective) may be reduced, depending on how soon after a similar event it occurs. A further important condition placed on the recommendation for higher flow events is the determination of an “independence” value – a period of time that may elapse between similar events.

For example, one objective of Low Flow Freshes is the flushing of fine sediment from in-stream habitats. A second Low Flow Fresh, soon after the first, may not have the same effect, as little or no sediment may have been deposited between the two freshes. Similarly, one of the functions of High Flow Freshes is to recruit leaves and twigs from in-stream benches to the stream channel. A second High Flow Fresh may not have the same effect as the first, depending on the amount of new material deposited on benches between the two events.

Hence, an independence recommendation is included, outlining the number of days that can pass before the next event is required. Higher flow events that occur during this independence period can be harvested without affecting either the identified ecological functions of the overall flow regime, or compliance with the recommendation. The independence value was based on an assessment of the list of flow-related processes for a particular flow component by the Technical Panel.

3. Environmental Objectives and Flow Requirements

3.1 Environmental Objectives

All of the environmental flow recommendations need to be tied to achieving a particular environmental objective for each river. Environmental objectives were established in Stage 1 of the project for geomorphology, fish, macroinvertebrates and riparian, floodplain vegetation and platypus:

- The environmental objectives for geomorphology are to “*maintain or improve channel form and processes for ecological benefit*”.
- The environmental objectives for fish communities are to “*maintain or restore self-sustaining populations of the major fish species in the systems*”.
- The environmental objectives for macroinvertebrate communities are to “*maintain or improve macroinvertebrate communities to meet State Environmental Protection Policy Schedule F7 guidelines*”.
- The environmental objectives for riparian and riverine vegetation are to “*maintain extant and restore degraded riparian and floodplain vegetation*”.
- The environmental objectives for platypus appropriate for this study are to: “*Maintain flow conditions suitable for platypus in the Little Yarra River*”.

3.2 Flow Requirements and assessment criteria

For each objective, a number of flow-related processes were identified that would contribute to achieving the overall objectives. These consisted of biological processes specific to a particular taxon or community (e.g. the provision of spawning triggers for small migratory fish species), broader ecological processes that relate to some or all taxa or communities (e.g. flushing flows to provide clean stream substrate condition or water quality), or those with indirect links to biodiversity (e.g. high flows to provide carbon cycling from benches). For each of the flow components outlined in Table 2.2, an association can be made with a specific flow-related process of each environmental objective (Table 3.1).

Table 3.1. Flow-related environmental process associated with each flow component to achieve the objectives in the Little Yarra and Don Rivers.

Flow Component	Flow-related process
Cease-to-Flows	<ul style="list-style-type: none"> • Not known in the natural flows for either river (however, natural frequency and duration achieved by cease to divert flow recommendation).
Low Flows	<ul style="list-style-type: none"> • Maintain habitat for aquatic macroinvertebrates; • Maintain habitat for all groups of fish; • Maintain water supply for drought sensitive plant species; • Maintain foraging habitat for platypus (Little Yarra River only).
Low Flow Freshes	<ul style="list-style-type: none"> • Allow local redistribution of all fish species; • Allow upstream movement of adult and juvenile migratory fish species; • Refresh water quality in pools; • Maintain adequate water quality for larval, juvenile and adult fish survival; • Scour surficial fine sediment from riffle surface (Don River only).
High Baseflow	<ul style="list-style-type: none"> • Maintain habitat for aquatic macroinvertebrates; • Maintain habitat for all groups of fish; • Maintain foraging habitat for platypus (Little Yarra River only); • Allow movement of migratory fish species and redistribution of small non-migratory fish species.

Flow Component	Flow-related process
High Flow Freshes	<ul style="list-style-type: none"> ● Bench inundation to deliver carbon to the stream; ● Maintain bank wetting regimes for bank side riparian understorey plants. ● Breeding and migration cues for migratory fish; ● Maintain channel form and key habitats, including in-channel benches; ● Movement of bed material to maintain bed diversity for water depth variation; ● Control riparian vegetation encroachment into stream channel; ● Prevent excessive macrophyte colonisation of the bed; ● Scour sediments from sand surfaces, in-stream habitats and base of pools (Little Yarra River only); ● Scour fine sediment from pools and riffles (Don River only); ● Biofilm scour to provide food for aquatic macroinvertebrates.
Bankfull Flows	<ul style="list-style-type: none"> ● Maintain channel form and key habitats, including in-channel benches; ● Bench inundation to deliver carbon to the stream; ● Control riparian vegetation encroachment into stream channel.
Overbank Flows	<ul style="list-style-type: none"> ● Inundate floodplain to deliver carbon and woody debris to the stream; ● Maintain channels and inlets for connectivity of main channel with important floodplain and wetland zones; ● Disturb riparian vegetation to provide new habitats and regeneration.

For each flow requirement, an assessment criterion was developed to evaluate whether or not a particular flow rate satisfied the function of the flow. These have been outlined in the Issues Paper.

4. Environmental Flow Recommendations

The flow recommendations for each reach are presented below in a standard format with four individual sections:

- **Flow Recommendations.** A discussion and justification of the various flows chosen for recommendation. A number of cross-section plots are presented for each reach with the flows recommended shown. These demonstrate where each flow would be expected to occur in the channel cross-section.
- **Summary Tables.** A summary of all the recommendations are presented in a seasonal table format that shows the recommendations in a easily visualised manner.
- **Achievement Tables.** The current flow data are examined to determine whether the flow recommendations are being achieved under the current management regime.
- **Supporting Recommendations.** These indicate non-flow related issues that require attention in order that the flow recommendations will achieve their intended objectives.

4.1 The Little Yarra River

Flow recommendations for the Little Yarra River are based on evaluations conducted at the Representative Site upstream of Britannia Creek. However, the gauge to be used for measuring compliance with environmental flows, and for managing diversions is downstream of Britannia Creek at Lowes Road (Gauge 229214). Additional hydrological modelling work will need to be conducted to establish a valid relationship between flows at the Representative Site and Gauge 229214.

Flow Recommendations

Low Flows

In the Little Yarra River, the low flow recommendation is based on providing adequate physical habitat for in-stream animals and plants living on the stream edge during the Low Flow Season (Table 4.1).

Table 4.1 Flow-related processes and assessment criteria for Low Flows in the Little Yarra River.

Flow Component	Flow-related process	Assessment criteria
Low Flows	<ol style="list-style-type: none"> 1. Maintain habitat for aquatic macroinvertebrates. 2. Maintain habitat for all groups of fish. 3. Maintain water supply for drought sensitive plant species. 4. Maintain foraging habitat for platypus. 	<ol style="list-style-type: none"> 1. Water to saturate all sand bed habitat in the Little Yarra River. 2. * Deep pool areas with >50% of wetted width deeper than 50 cm in the Little Yarra River. * Other areas with some water deeper than 20 cm, for smaller fish species. 3. Water to saturate edge of sand bed habitats in the Little Yarra River 4. As for fish and macroinvertebrates.

The flow that provided adequate physical habitat was assessed as that which:

- Provided at least 50% of the width of deep pool areas with depths over 50 cm, primarily for large River blackfish;
- Provided at least some water deeper than 20 cm in other areas, for small fish species;
- Completely covered the sand bed of the stream to any depth (both for macroinvertebrates and plants growing at the edge of the stream).

Three distinct pool areas were identified in the Little Yarra River Representative Site to evaluate deep water habitat for fish, particularly larger non-migratory species such as River blackfish (Figure 4.1). To achieve depths over 50 cm in each of these transects requires a flow of over 20 ML/d (Table 4.2). Only at a flow of 35 ML/d does the amount of habitat for fish reach the 50% assessment criteria in all three transects.

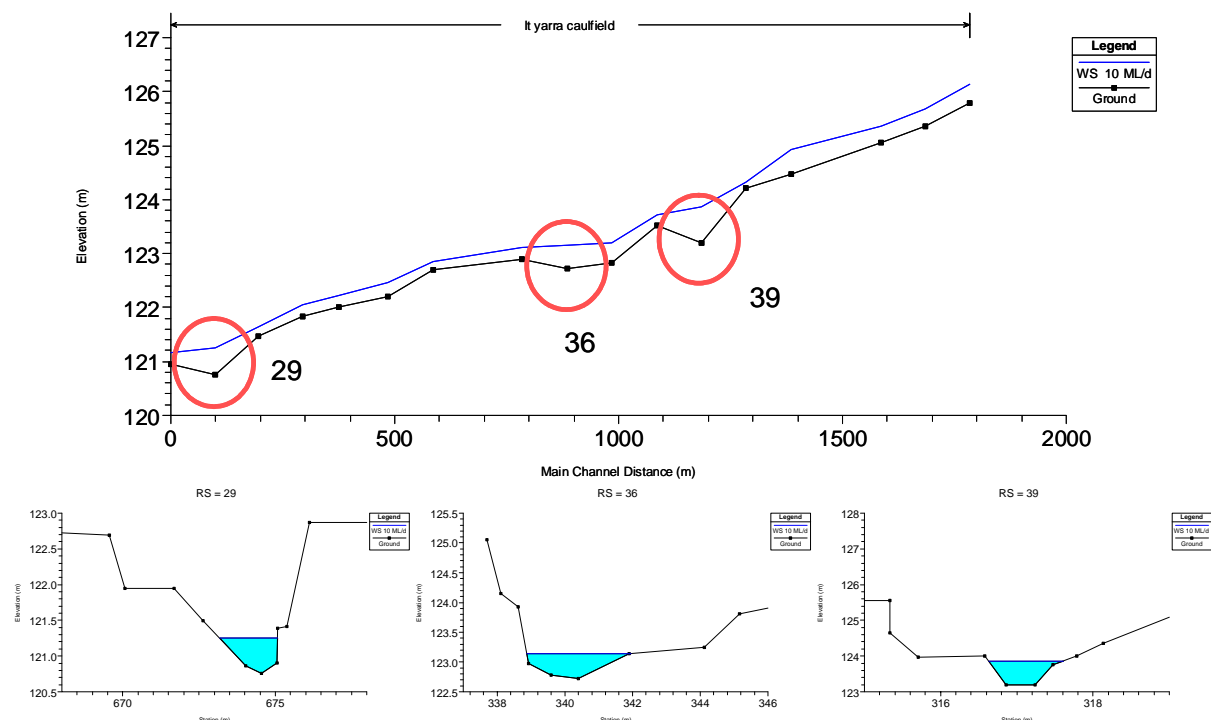


Figure 4.1 Top: Long profile showing location of three deeper areas (transects 29, 36 and 39). Bottom: Channel detail of cross sections of the three deeper areas (29 left; 36 centre and 39 right). Shown with a flow of 10 ML/d – the lowest natural flow in the Little Yarra River.

Table 4.2 Maximum depth and percentage of water deeper than 50 cm at three transects in Figure 4.1, at 5 different flows.

Flow (ML/d)	Transect 29		Transect 36		Transect 39	
	Max. depth (cm)	% > 50 cm	Max. depth (cm)	% > 50 cm	Max. depth (cm)	% > 50 cm
10	49	0	43	0	67	52
15	56	20	48	0	74	52
20	60	40	56	15	79	52
30	68	51	60	42	86	52
35	71	53	64	50	89	53

The flow of 35 ML/d also provides at least some habitat deeper than 20 cm in all the other transects for small bodied fish (with maximum depths ranging from 25-64 cm), covers the entire bed width and reaches the edge of the stream in all transects (Figure 4.2).

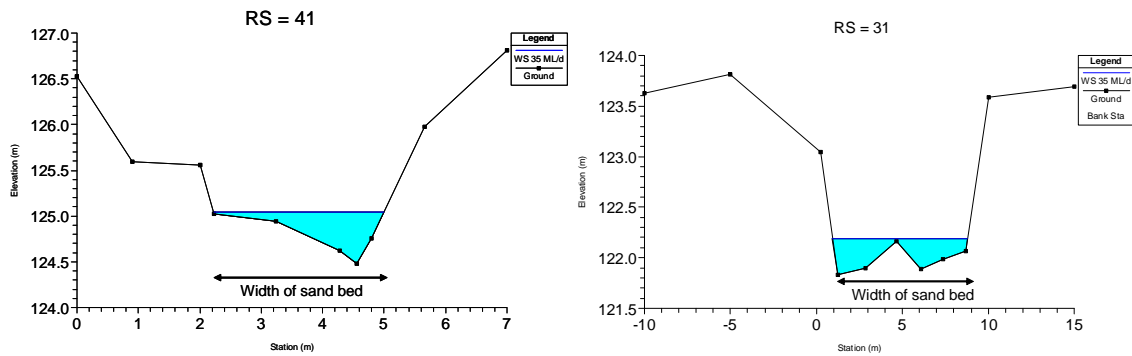


Figure 4.2 Two example transects showing a flow of 35 ML/d inundating the entire bed width (left) and mid-channel bars (right).

Therefore, a flow of 35 ML/d is recommended as a suitable cease to divert flow at the Representative Site during the Low Flow Season. This corresponds to a flow of just over 42 ML/d at stream gauge 229214².

The requirement for a flow decrease in the transitional High-Low flow season (Table 3.1) means that the cease to divert flow recommendation in the Little Yarra River covers the period December to May (which includes the transitional season and the Low Flow Season - Table 2.3).

Cease to Divert flow recommendation for the Little Yarra River:

- ✱ **Flow: 35 ML/d**
- ✱ **Timing: December to May inclusive**

Low Flow Freshes

Low Flow Freshes are small and short duration flow events that exceed the baseflow and last for at least several days during the Low Flow Season. They are caused by small localised summer storms. Low Flow Freshes have a number of different functions – maintaining and cleaning habitats, refreshing water quality and allowing the redistribution of fish species (Table 4.3).

Table 4.3 Flow-related processes and assessment criteria for Low Flow Freshes in the Little Yarra River

Flow Component	Flow-related process	Assessment criteria
Low Flow Freshes	<ol style="list-style-type: none"> Local redistribution of all fish species. Upstream movement of adult and juvenile migratory fish species. Maintain adequate water quality for larval, juvenile and adult fish survival. Refresh water quality in pools. 	<ol style="list-style-type: none"> At least 25% width of shallowest transect with depth > 12 cm for small fish movement . At least 25% width of shallowest transect with depth > 12 cm for small fish movement . Average water velocity >0.1 m/sec in shallow pools. Average water velocity >0.1 m/sec in shallow pools.

² Based on an upstream catchment area comparison between the Representative Site and the stream gauge (as outlined in the Issues Paper)

The initial assessment involved determining the flow that would satisfy the criteria for the local redistribution of small fish at the shallowest transect (the cross section that determines the ability of fish to move through the reach). No criterion has been applied for passage of adult River blackfish, as they are not thought to require movement during this period (the main period for movement is coming up to the breeding season in November).

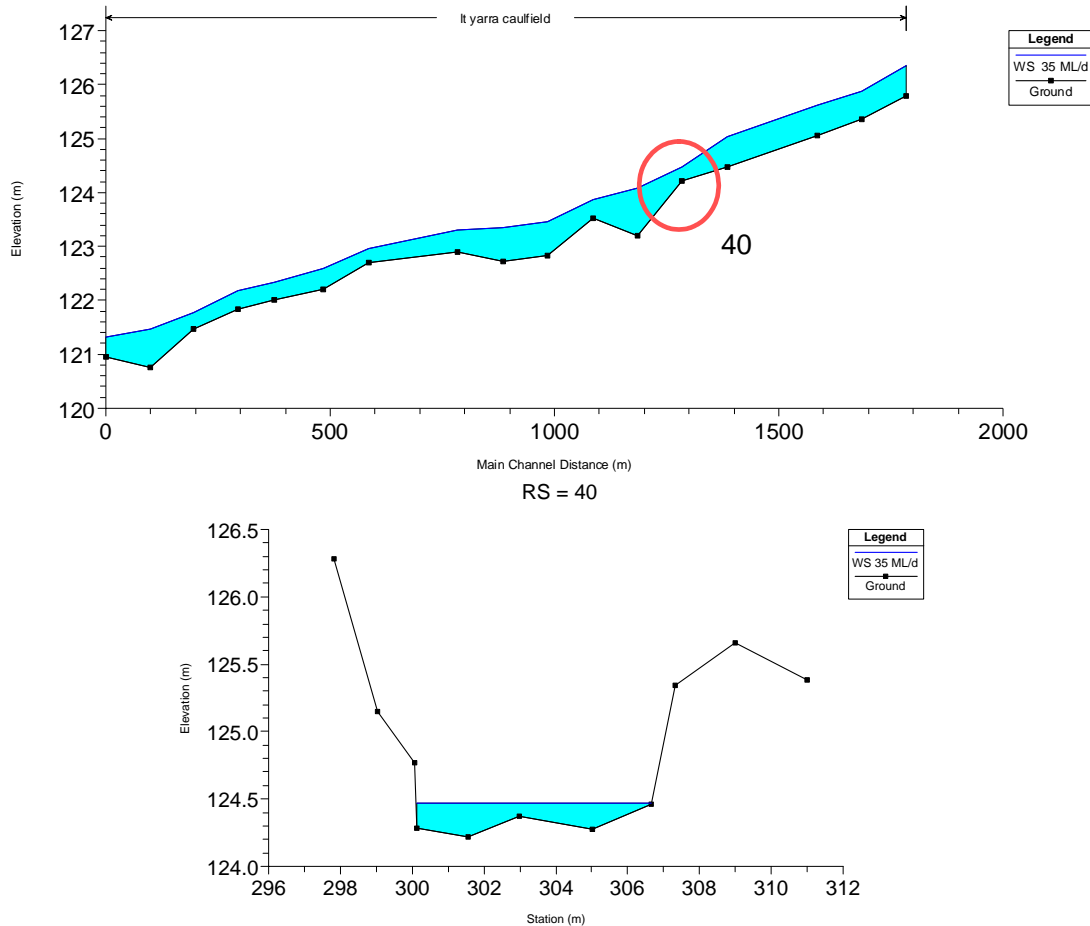


Figure 4.3 Top: Long profile showing location of shallowest cross section (transect 40) at the cease to divert flow of 35 ML/d. Bottom: Cross section of transect 40.

At the cease to divert flow of 35 ML/d, the maximum depth in transect 40 is 25 cm. The proportion of the water width with depths greater than 12 cm (providing passage for small fish) is 72%. Incidentally, the proportion of the water width with depths greater than 20 cm (providing passage for larger fish) is 24%. All other reaches have greater than 25% of the water width deeper than 20 cm.

Average channel velocity in all transects at 35 ML/d range from 0.2-1.3 m/sec, suggesting fish passage would be manageable at this flow. As the average channel velocity in all transects is positive, the flow of 35 ML/d also fulfils the assessment criterion for water quality.

As the ecological criteria for Low Flow Freshes are met at the cease to divert flow of 35 ML/d, there appears to be no reason for recommending specific Low Flow Freshes in the Little Yarra River.

Low Flow Fresh recommendation for the Little Yarra River:

✳ No recommendation required

High Baseflow

High Baseflow refer to the persistent increase in baseflow that occurs with the onset of the wetter months of the year. These are flows that cover the bed and some of the low in-channel benches.

Like the Low Flows, a major function of the High Baseflow recommendation is to maintain habitat for in-stream biota (Table 4.4), meaning that the recommendation should be at least the same level as the Low Flow recommendation (a cease to divert flow of 35 ML/d).

Table 4.4 Flow-related processes and assessment criteria for High Baseflows in the Little Yarra River

Flow Component	Flow-related process	Assessment criteria
High Baseflow	<ol style="list-style-type: none"> Maintain habitat for aquatic macroinvertebrates. Maintain habitat for all groups of fish. Migration of migratory fish species and mixing of small and large non-migratory fish species.. Maintain foraging habitat for platypus. 	<ol style="list-style-type: none"> Water to saturate all sand bed habitat in the Little Yarra River. * Deep pool areas with >50% of wetted width deeper than 50 cm in the Little Yarra River. * Other areas with some water deeper than 20 cm, for smaller fish species. * High Flow recommendation higher than Low Flow in June; * At least 25% width of shallowest transect with depth required for fish movement of 12 cm for small fish and 20 cm for large fish. As for fish and macroinvertebrates.

However, another major consideration is that High Baseflows allow for the large scale migration of any migratory species (e.g. movement of Common galaxias from the Little Yarra River to the Yarra River estuary), and the small scale mixing of non-migratory fish populations prior to breeding (e.g. River blackfish in late spring). A rise in water level during Transitional and early High Flow periods (say, June to August in the Little Yarra River) was initially considered necessary to allow movement of fish.

As for Low Flows, the High Baseflow recommendation is specified as a cease to divert flow. This should be a flow that both provides adequate habitat, and allows fish passage through the entire reach.

In fact, the Low Flow recommended cease to divert flow of 35 ML/d is satisfactory as a High Flow recommendation. Both adequate habitat, and provision for fish passage for all species are provided at that flow. Therefore an increase in the recommendation over the High Flow Season is not considered necessary.

Cease to Divert flow recommendation for the Little Yarra River:

- * **Flow: 35 ML/d**
- * **Timing: June to November inclusive**

High Flow Freshes

High Flow Freshes refer to long sustained increases in flow during the high flow period as a result of sustained or heavy rainfall events. High Flow Freshes have a number of functions in the stream (Table 4.5), particularly to inundate benches and banks, create scour disturbance in the channel, and act as triggers for fish migration/breeding.

The initial assessment involved identifying benches in transects and determining the flows required to inundate them. Characteristics of these flows were then examined to determine whether they would satisfy other assessment criteria.

Table 4.5 Flow-related processes and assessment criteria for High Flow Freshes in the Little Yarra River.

Flow Component	Flow-related process	Assessment criteria
High Flow Freshes	1. Bench inundation to deliver carbon to the stream;	1. Morphological criteria based on benches.
	2. Maintain bank wetting regimes for bank side riparian understorey plants.	2. Morphological criteria based on transect features.
	3. Breeding and migration cues for migratory fish;	3. No specific criterion (but freshes are required to initiate spawning).
	4. Maintain channel form and key habitats, including in-channel benches;	4. Stream power during fresh capable of moving sand ($\tau_c > 15 \text{ N/m}^2$).
	5. Movement of sand bed material to maintain bed diversity for water depth variation;	5. Stream power capable of moving sand sediments ($\tau_c > 15 \text{ N/m}^2$).
	6. Control riparian vegetation encroachment into stream channel;	6. Stream power during fresh capable of disturbing sand bars ($\tau_c > 15 \text{ N/m}^2$).
	7. Prevent excessive macrophyte colonisation of the bed;	7. Stream power during fresh capable of disturbing sand bars ($\tau_c > 15 \text{ N/m}^2$).
	8. Scour sediments from sand surface, in-stream habitats and base of pools;	8. Bed shear stress during fresh capable of moving silt from a sand bed ($\tau_c > 8 \text{ N/m}^2$).
	9. Biofilm scour to provide food for aquatic macroinvertebrates.	9. No known criterion (other scour criteria considered adequate).

A number of benches, including low channel and high channel benches were identified in the Little Yarra River transects (Figure 4.4, Figure 4.5). A flow of 200 ML/d was identified as suitable to inundate all of the low channel benches (Figure 4.4) and 500 ML/d was identified as suitable to inundate the high channel benches (Figure 4.5).

The flow of 200 ML/d would appear to satisfy all other assessment criteria for channel scour and disturbance. The shear required to entrain sand would be considered to be 15 N/m^2 or less. At 200 ML/d channel scour values range from 3.7 to 112 N/m^2 , with 10 of the 17 values greater than 15 N/m^2 . Since shear values provided by the hydraulic model are a transect average, the shear would be expected to be considerably higher in some parts of the channel, particularly around obstructions such as LWD, allowing for channel variability and satisfying many of the channel form objectives. The shear values for the sections of flow over the stream bank and benches range from $0.5 - 37 \text{ N/m}^2$, and the average velocity of water flowing over the banks and benches ranges from $0.05 - 0.95 \text{ m/sec}$. These indicative values suggest that the flows should be adequate.

Although no criteria can be set for determining flows suitable as cues for fish breeding and migration, it is assumed that a flow of 200 ML/d represents a sufficient change from baseflow to initiate these events. One additional requirement for fish breeding and migration cues is that the first such flow in the Transitional or early High Flow Season (June to August) needs to be preserved to provide a spawning/migration cue as early as possible.

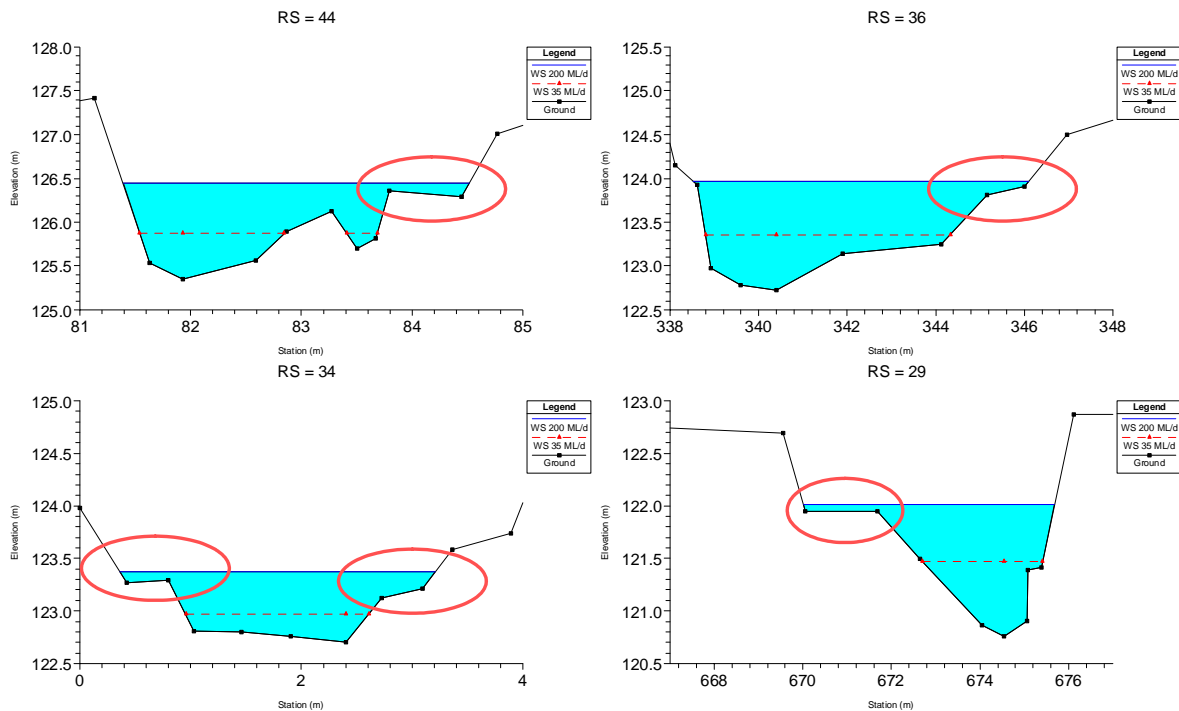


Figure 4.4 Channel detail with examples of low channel benches identified in the Little Yarra River and flows of 200 ML/d (filled) and the cease to divert flow of 35 ML/d (red dotted).

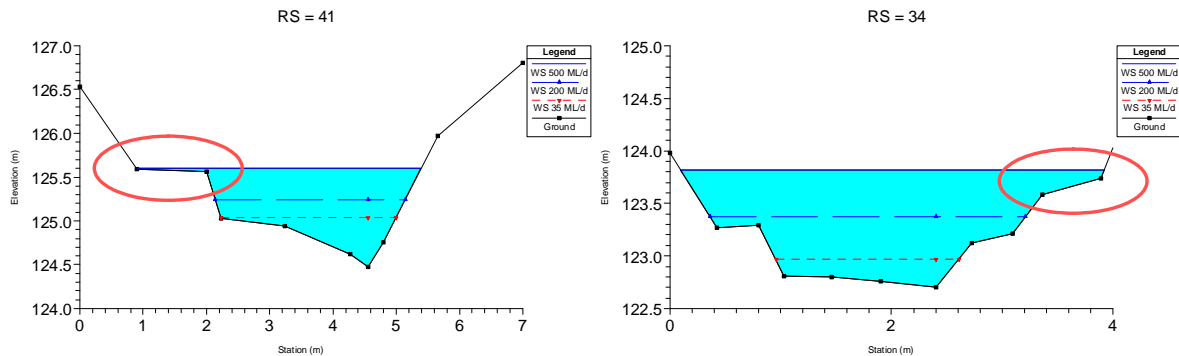


Figure 4.5 Channel detail with examples of high channel benches identified in the Little Yarra River and flows of 500 ML/d (filled), 200 ML/d (dashed) and the cease to divert flow of 35 ML/d (red dotted).

Flows of 200 ML/d or more naturally occurred between 1963-2003 at the Representative Site at a median frequency of 7 times a year, each spell occurring at a median duration of 2 days.

Flows of 500 ML/d or more naturally occurred between 1963-2003 at the Representative Site at least once in 17 years out of 41 years (rounded up to 1 in 3 years³), each spell occurring at a median duration of 1 day.

None of the flow-related processes associated with High Flow Freshes (Table 4.5) would indicate an appropriate independence value. An arbitrary independence value of 14 days was selected for the 200 ML/d flow, in part to provide for a series of fish breeding/migration cues, especially over the early part of the June to November period.

³ The recommendation is rounded up rather than down to 1 in 2 years, because if the current flow had the same frequency as the natural flow, it would not technically be in compliance with a 1 in 2 year frequency.

High Flow Fresh recommendation for the Little Yarra River:

- ✱ **Flow: 200 ML/d, 7 per year, 2 days duration;**
- ✱ **Timing: June to November inclusive;**
- ✱ **First High Flow Fresh between June and August to be preserved;**
- ✱ **Independence: 14 days**

High Flow Fresh recommendation for the Little Yarra River:

- ✱ **Flow: 500 ML/d, 1 in 3 years, 1 day duration;**
- ✱ **Timing: June to November inclusive;**

Bankfull and Overbank Flows

Bankfull Flows fill the channel, but do not spill onto the floodplain. They have mainly geomorphological functions, maintaining the channel shape and form (Table 4.6). Overbank flows are higher than the bankfull flows, and spill out of the channel onto the floodplain. These are ecologically important for stream associated wetlands, for bringing carbon (dissolved from the floodplain floor, or in the form of leaves and twigs) or woody debris from the floodplain to the stream channel, and for disturbing the riparian vegetation (Table 4.6).

A flow of 750 ML/d was determined as the bankfull flow (Figure 4.6). Flows of 750 ML/d or more were only recorded in 6 years out of 41 (1963-2003), rounded up to 1 in 7 years.

Table 4.6 Flow-related processes and assessment criteria for Bankfull and Overbank Flows in the Little Yarra River

Flow Component	Flow-related process	Assessment criteria
Bankfull Flows	<ol style="list-style-type: none"> 1. Inundate floodplain to deliver carbon and woody debris to the stream; 2. Bench inundation to deliver carbon to the stream; 3. Maintain channel form and key habitats, including in-channel benches; 4. Maintain channels and inlets for connectivity of main channel with important floodplain and wetland zones; 5. Disturb riparian vegetation to provide new habitats and regeneration. 	All – Morphological criteria based on transect features for bankfull

Bankfull and Overbank Flow recommendation for the Little Yarra River:

- ✱ **Flow: greater than or equal to 750 ML/d, 1 in 7 years, 1 day duration**
- ✱ **Timing: Any time of year**

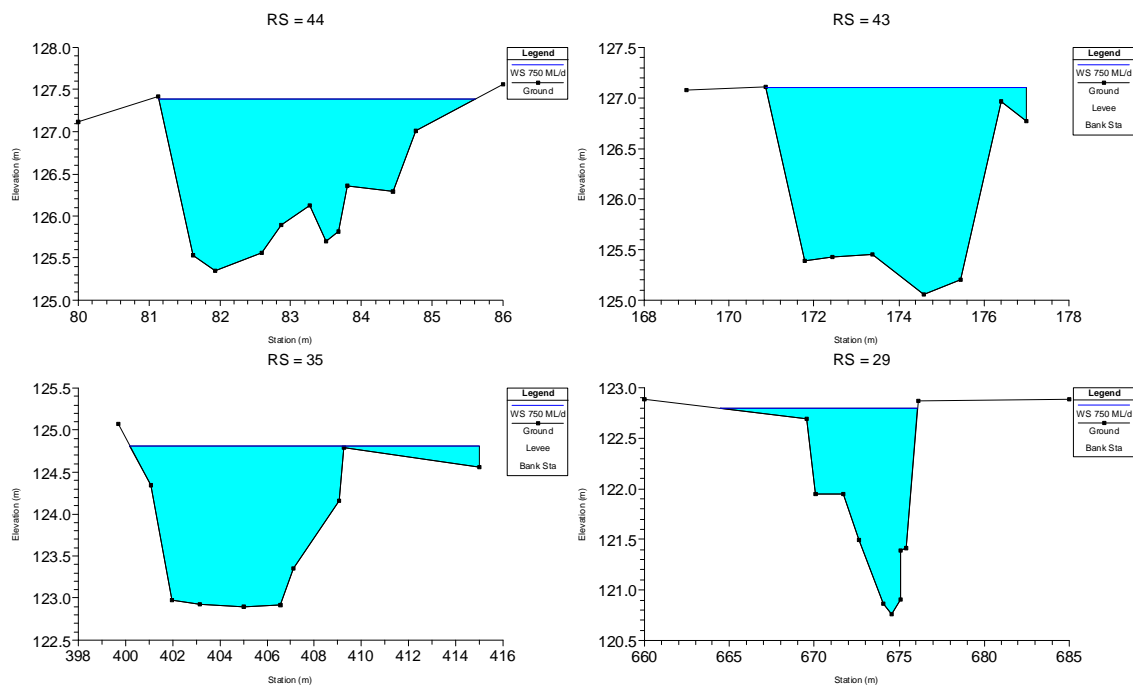


Figure 4.6 Selected transects at a flow of 750 ML/d.

Summary of environmental flow recommendations for the Little Yarra River

Table 4.7 Summary of environmental flow recommendations in the Little Yarra River.

Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
T	Low Flow Season					T	High Flow Season				
Cease to Divert Flow: 35 ML/d											
						High Flow Fresh: 200 ML/d, 7 per year, 2 days					
						High Flow Fresh: 500 ML/d, 1 year in 2, 2 days					
Bankfull and Overbank Flow: 750 ML/d, 1 year in 7, 1 day											

Achievement of environmental flow recommendations for the Little Yarra River

The recommended flows in the summary table above were compared with the current flows modelled for the Little Yarra River (Table 4.8). It is important to note that the modelling of current flows do not include any interim flow management arrangements (such as the cease to divert flows presently in place), and assume no environmental flow rules are in operation.

The recommended cease to divert flow is not achieved in the Little Yarra River as lower flows are currently recorded considerably more frequently than under natural conditions. The inclusion of a cease to divert flow of 35 ML/d at the Representative Site (regulated by a cease to divert flow of 42 ML/d at streamflow gauge 229214) in the Little Yarra River Streamflow Management Plan would ensure that this recommendation was met.

All of the High Flow Fresh and Bankfull and Overbank Flow recommendations are achieved at the current level of development.

Table 4.8 Achievement table for environmental flow recommendations in the Little Yarra River.

Season	Recommendation	Evaluation	Achievement
All year	Cease to Divert flow 35 ML/d	Naturally lower than 35 ML/d, 61 times in 41 years, 6 day median Currently lower than 35 ML/d, 126 times in 41 years, 4 day median ⁴	Not achieved, lower flows too frequent
Jun - Nov	High Flow Freshes: >200 ML/d, 7 per year, 2 days	Currently 7 times per year, 2 days median	Achieved
Jun - Nov	High Flow Freshes: >500 ML/d, 1 year in 2, 1 day	Currently 17 times in 41 years, 1 day median	Achieved
All year	Bankfull and Overbank Flows: >750 ML/d, 1 year in 7, 1 day	Currently 6 times in 41 years, 1 day median	Achieved

Supporting Recommendations

Barriers to Fish Migration

- The in-stream barrier present in the lower Little Yarra River (gauging weir) is likely to prevent colonisation of migratory fish except under very high flow conditions. For the environmental flow objectives for fish to be achieved, a functioning fishway will need to be installed at this barrier.

Riparian Vegetation Management

- Riparian and floodplain vegetation has been widely cleared and/or grossly modified in sections of the Little Yarra River. Riparian Forest, Riparian Scrub, Swampy Riparian Complex and Damp Heathy Woodland EVCs have been extensively cleared throughout southern Victoria. The restoration of riparian and some floodplain vegetation in cleared areas should be a long term objective.
- Riparian vegetation also forms an important food source for the food chain in the Little Yarra River. Restoring riparian vegetation, where it is disturbed or absent, will improve the conditions of the food chain in the river.
- Riparian vegetation also provides the major source of Large Woody Debris (LWD) to the channel. LWD encourages diversity in the bed form and variation in water depth for in-stream habitat, and reduces the energy of the flow leading to a reduction in bank erosion. Removal of LWD should be prevented, unless otherwise demonstrated as a serious threat to a high value asset or human life. Reinstatement should be considered (as with the current LWD reinstatement project on the Little Yarra River) and riparian stands providing potential future sources of LWD should be maintained or regenerated.
- Willow trees that colonise sections of the Little Yarra River have extensive root systems that can readily colonise the stream banks and bed, creating constrictions and resulting in catastrophic erosion at higher flows. Willow colonisation should be managed to maintain natural channel form and stability.
- Numerous serious environmental weed species were noted during the field investigation. There is currently no evidence of weed control effort on either public or private land. Weed management is urgently required to maintain the significant vegetation values and natural stream forms along the river and to prevent or impede the further spread into as yet un-invaded areas.

⁴ The current flows are modelled with no environmental flow recommendations (i.e. do not include any interim flow conditions)

Stock Management

- Direct trampling and disturbance from unrestricted stock access leads to increased erosion and channel change through the removal of stabilising ground and understorey cover of riparian vegetation, and the creation of flow pathways for sediment transfer. Stock access to streams should be minimised or curtailed through fencing of the riparian zone. This includes fencing of wetland or boggy areas adjacent or connected to the tributaries of the Little Yarra River.

Water Quality Management

- A high level of water quality needs to be maintained to protect and enhance in-stream environments. Some storm related declines in water quality have been noted in the Little Yarra River, possibly due to stock waste and septic in-flows (Coleman and Amenta, 2001). The Technical Panel believes that flow manipulation (i.e. providing dilution flows) to address water quality issues is an inappropriate use of a valuable water resource, and such water quality problems should be tackled and managed at their source.
- Sources of excess sedimentation (such as from un-made road crossings or eroding banks) need to be reduced wherever they occur (including forestry areas upstream of Powelltown).

Groundwater Management

- Although recommendations on groundwater management are beyond the scope of this project, it needs to be recognised that excessive ground water extractions will have a significant impact on seasonal baseflows, and spring or ground water dependant communities. Management of groundwater extractions in the Little Yarra River will need to take any potential impact on seasonal baseflows into account.

4.2 The Don River

Flow recommendations for the Don River are based on evaluations conducted at the Representative Site upstream of Dalry Road. However, there is no gauge for measuring compliance with environmental flows, and for managing diversions. A new gauge will need to be constructed, and a relationship established between flows at the Representative Site and the new gauge.

Flow Recommendations

Low Flows

In the Don River, the low flow recommendation is based on providing adequate physical habitat for in-stream animals and plants living on the stream edge during the Low Flow Season (Table 4.9).

Table 4.9 Flow-related processes and assessment criteria for low flows in the Don River.

Flow Component	Flow-related process	Assessment criteria
Low Flows	<ol style="list-style-type: none"> Maintain habitat for aquatic macroinvertebrates. Maintain habitat for all groups of fish; Maintain water supply for drought sensitive plant species. 	<ol style="list-style-type: none"> Water depth up to 10 cm in riffle areas of the Don River. Deep pool areas with >50% of wetted width deeper than 40 cm in the Don River. Water to saturate edge habitats in the Don River

The flow that provided adequate physical habitat was assessed as that which:

- Provided at least 50% of the width of deep pool areas with depths over 40 cm, for River blackfish and other smaller fish;
- Provided water depths up to 10 cm in riffle areas; and
- Completely covered the bed of the stream to any depth (both for macroinvertebrates and plants growing at the edge of the stream).

Two distinct pool areas were identified in the Don River Representative Site (Figure 4.7) to evaluate deep water habitat for fish (both River blackfish and smaller fish).

Analysis of typical low flows showed that the pool at transect 10 did not meet the depth criterion, even at relatively high flows (Table 4.10 – 10 ML/d is about the 60th percentile exceedence annual flow), while transect 4 just met the criterion at this flow. This suggested that the Don River may not be ideal habitat for River blackfish (even under natural flows, there would be little optimal habitat for blackfish), and so the Low Flow cease to divert recommendation was determined on the basis of providing adequate depth for smaller fish species in the pools, and for macroinvertebrate in riffles.

Table 4.10 Maximum depth and percentage of water deeper than 40 cm at two transects in Figure 4.7, at 6 different flows

Flow (ML/d)	Transect 4		Transect 10	
	Max. depth (cm)	% > 40 cm	Max. depth (cm)	% > 40 cm
1	45	26	36	0
2	51	40	37	0
3	53	45	37	0
4	55	46	38	0
5	56	46	39	0
10	60	50	42	16

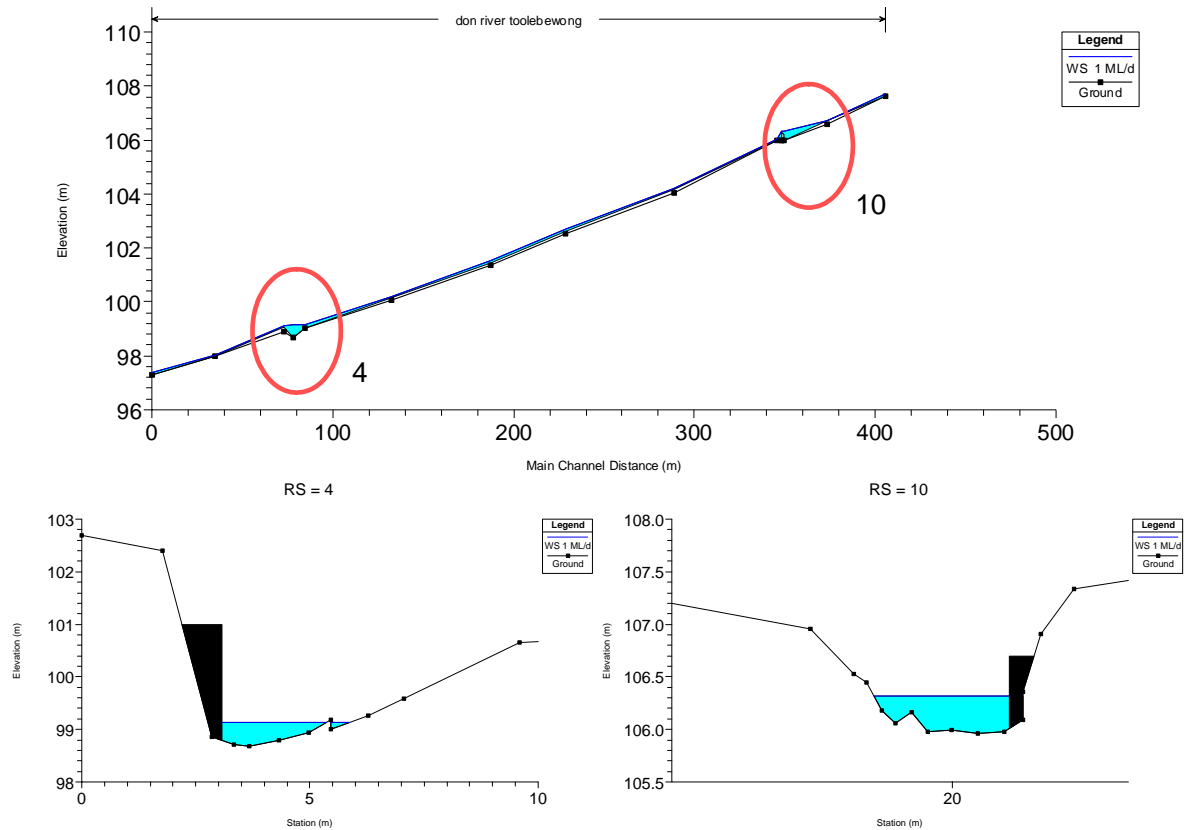


Figure 4.7 Top: Long profile showing location of two deeper areas (transects 4, and 10). Bottom: Channel detail of cross sections of the two deeper areas (4 left; 10 right). Shown with a flow of 1 ML/d – near the lowest natural flow in the Don River of 0.6 ML/d.

Under all the flows in Table 4.10, water deeper than 20 cm in the two pools would be available for small fish, so a number of typical riffle areas were examined to determine flows that would provide a variety of depths up to 10 cm deep for macroinvertebrates (Figure 4.8). A flow of 3 ML/d provided a maximum depth of at least 10 cm at all of the transects (Table 4.11).

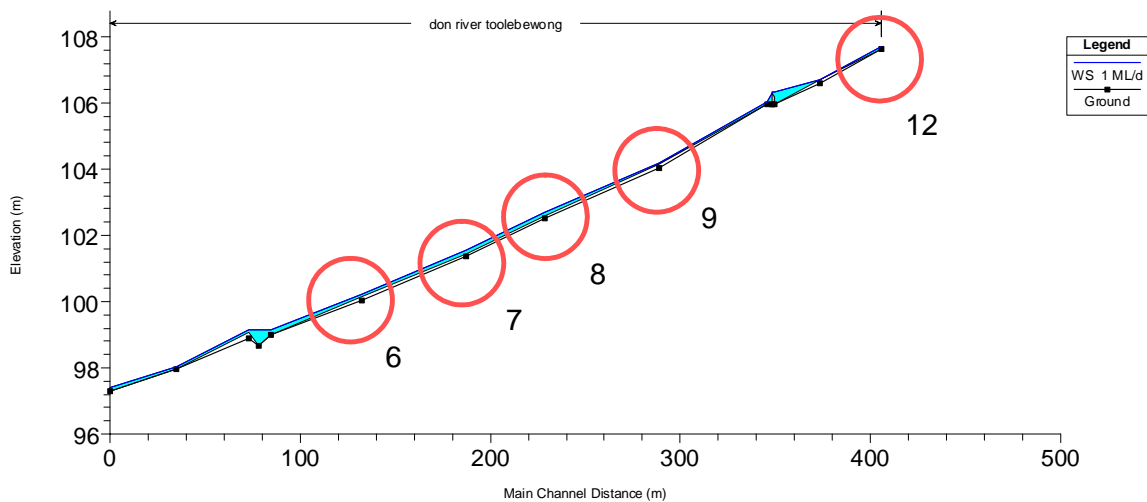


Figure 4.8 Long profile showing location of riffle areas examined.

Table 4.11 Maximum water depth at each of the 5 riffle transects from Figure 4.8 at 6 different flows.

Flow (ML/d)	6	7	8	9	12
1	7	9	10	5	8
2	10	12	15	7	11
3	13	14	19	10	12
4	15	16	23	12	14
5	17	18	26	13	15
10	25	27	38	26	20

The flow of 3 ML/d also inundated most of the bottom channel width and would thus provide an adequate water source for edge dwelling plants (Figure 4.9).

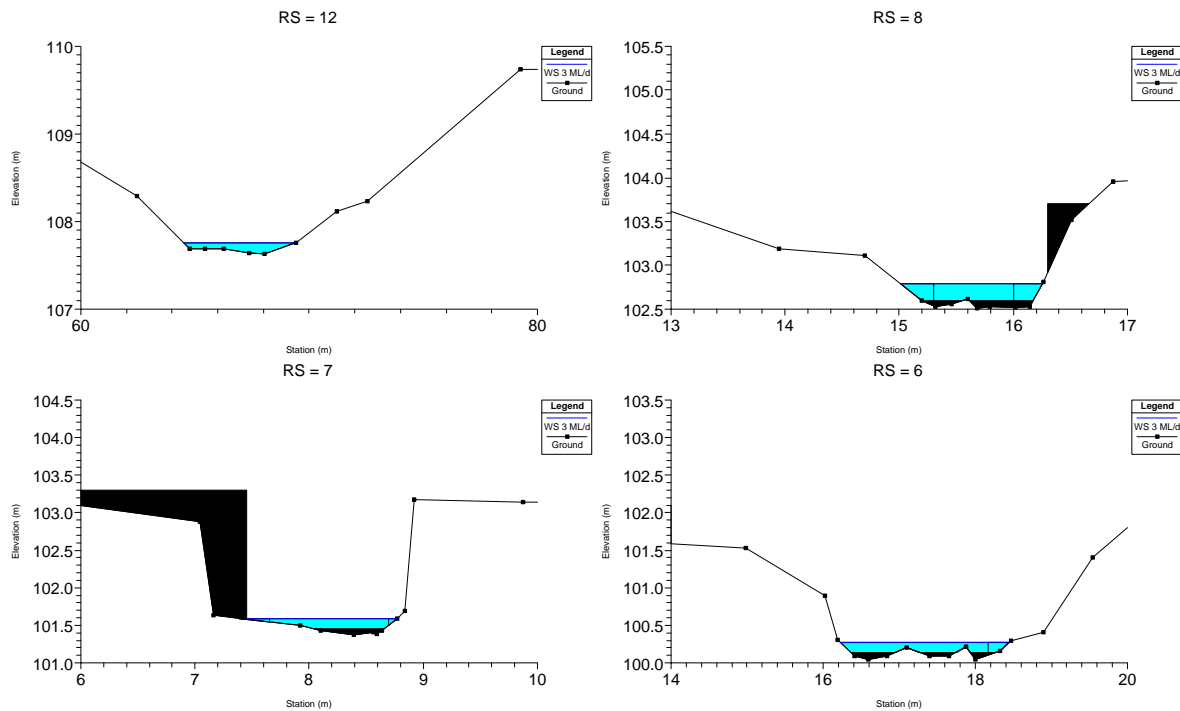


Figure 4.9 Channel detail of cross sections of four riffle areas with a flow of 3 ML/d.

Therefore, a flow of 3 ML/d is a suitable cease to divert flow at the Representative Site for the Low Flow Season.

The requirement for a flow decrease in the transitional High-Low flow season (Table 3.1) means that the Low Flow recommendation in the Don River is for the period January to May (which includes the transitional season and the Low Flow Season - Table 2.3).

Cease to Divert flow recommendation for the Don River:

- ✱ **Flow: 3 ML/d**
- ✱ **Timing: January to May inclusive**

Low Flow Freshes

Low Flow Freshes are small and short duration flow events that exceed the baseflow and last for at least several days during the Low Flow Season. They are caused by small localised summer storms. Low Flow Freshes have a number of different functions – maintaining and cleaning habitats, refreshing water quality and allowing the redistribution of fish species (Table 4.12).

The initial assessment involved determining the flow that would satisfy the criteria for the local redistribution of all fish at the shallowest transect (the cross section that determines the ability of fish to move through the reach).

Table 4.12 Flow-related processes and assessment criteria for Low Flow Freshes in the Don River

Flow Component	Flow-related process	Assessment criteria
Low Flow Freshes	<ol style="list-style-type: none"> 1. Local redistribution of small fish species. 2. Upstream movement of adult and juvenile migratory fish species. 3. Scour fine sediments from riffle surfaces. 4. Maintain adequate water quality for larval, juvenile and adult fish survival. 5. Refresh water quality in pools. 	<ol style="list-style-type: none"> 1. At least 25% width of shallowest transect with depth > 12 cm for small fish movement. 2. At least 25% width of shallowest transect with depth > 12 cm for small fish movement. 3. Bed shear stress during fresh capable of moving silt from a cobble bed ($\tau_c > 15 \text{ N/m}^2$). 4. Average water velocity of >0.1 m/s capable of overturning water in shallow pools . 5. Average water velocity of >0.1 m/s capable of overturning water in shallow pools .

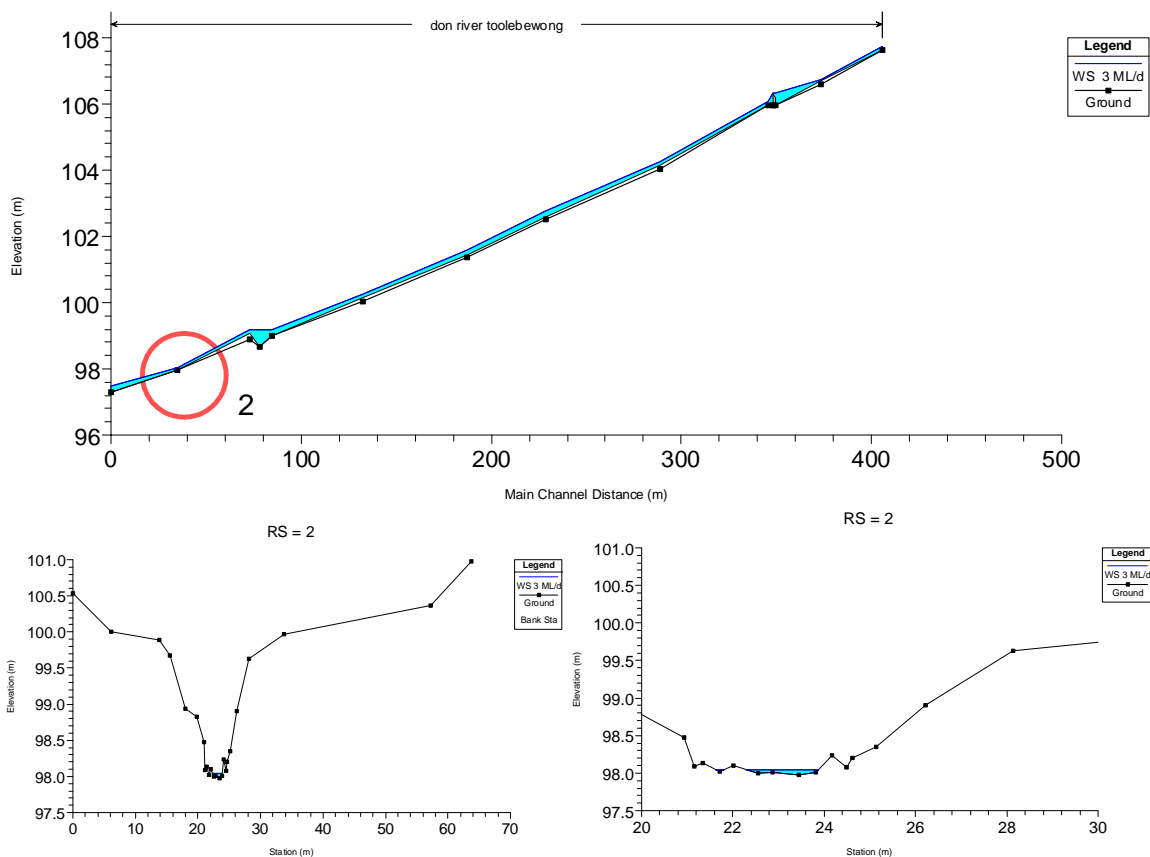


Figure 4.10 Top: Long profile showing location of shallowest cross section (transect 2) at the cease to divert flow of 3 ML/d. Bottom: Cross section of transect 2 (full transect and detail).

A water depth of over 12 cm was not achieved in any part of transect 2 until the flow reached 8 ML/d (Table 4.13), but provided almost no width for passage. A flow of 9 ML/d only provided 15% of the wetted width with available fish passage. At a flow of 10 ML/d, 45% of the wetted width of the channel is available for passage of small fish, suggesting it to be an appropriate Low Flow Fresh recommendation.

Table 4.13 Maximum depth and the proportion of wetted width deeper than 12 cm in transect 2 at 4 flows.

Flow	Maximum depth (cm)	% >12 cm
8	13	<1
9	14	15
10	15	45
11	16	47

The fish passage requirements for Low Flow Freshes in the Don River is therefore achieved at a flow of 10 ML/d. At this flow, the average channel velocity in all transects is positive, fulfilling the assessment criterion for water quality.

At 10 ML/d, total channel shear (a measure of the ability to move particles) in all but one riffle transects is higher than 15 N/m², suggesting that fine particles would easily be moved at this flow.

The Low Flow Fresh recommendation for the Don River is therefore 10 ML/d.

Flows of 10 ML/d or more naturally occurred between January to May (1964-2003) in the Don River at a median frequency of 3 times a year, each spell occurring at a median duration of 9 days.

None of the flow-related processes associated with Low Flow Freshes (Table 4.12) would indicate an appropriate independence value. An arbitrary independence value of 7 days was selected.

Low Flow Fresh recommendation for the Don River:

- ✱ **Flow: 10 ML/d, 3 per year, 9 days**
- ✱ **Timing: January to May inclusive**
- ✱ **Independence: 7 days**

High Baseflow

High Baseflow refer to the persistent increase in baseflow that occurs with the onset of the wetter months of the year. These are flows that cover the bed and some of the low in-channel benches.

Like the Low Flows, a major function of the High Baseflow recommendation is to maintain habitat for in-stream biota, but also to provide for permanent fish passage for migratory fish species and mixing of non-migratory species prior to breeding (Table 4.14). This suggests that the recommendation should be at least the same level as the Low Flow Fresh recommendation (10 ML/d).

As the river is considered to be sub-optimal for River blackfish, permanent passage for that species is not deemed necessary during the High Flow Season. Rather, passage for any individuals should be provided for on an occasional basis by High Flow Freshes (see next section).

Table 4.14 Flow-related processes and assessment criteria for High Flows in the Don River.

Flow Component	Flow-related process	Assessment criteria
Low Flows	<ol style="list-style-type: none"> 1. Maintain habitat for aquatic macroinvertebrates. 2. Maintain habitat for all groups of fish; 3. Maintain water supply for drought sensitive plant species. 4. Migration of migratory fish species and mixing of small and large non-migratory fish species 	<ol style="list-style-type: none"> 1. Water depth up to 10 cm in riffle areas of the Don River. 2. Deep pool areas with >50% of wetted width deeper than 40 cm in the Don River. 3. Water to saturate edge habitats in the Don River. 4. * At least 25% width of shallowest transect with depth > 12 cm for small fish movement.

The requirement for a flow increase in the transitional Low-High flow season (Table 3.1) means that the High Baseflow recommendation in the Don River is for the period June to December (which includes the Transitional Low to High flow season and the High Flow Season - Table 2.3).

Cease to Divert flow recommendation for the Don River:

- * **Flow: 10 ML/d**
- * **Timing: June to December inclusive**

High Flow Freshes

High Flow Freshes refer to long sustained increases in flow during the high flow period as a result of sustained or heavy rainfall events. High Flow Freshes have a number of functions in the stream (Table 4.15).

Table 4.15 Flow-related processes and assessment criteria for High Flow Freshes in the Don River.

Flow Component	Flow-related process	Assessment criteria
High Flow Freshes	<ol style="list-style-type: none"> 1. Bench inundation to deliver carbon to the stream; 2. Maintain bank wetting regimes for bank side riparian understorey plants. 3. Breeding and migration cues for migratory fish; 4. Maintain channel form and key habitats, including in-channel benches; 5. Movement of bed material to maintain bed diversity for water depth variation; 6. Control riparian vegetation encroachment into stream channel; 7. Prevent excessive macrophyte colonisation of the bed; 8. Scour sediments from pools and riffles; 9. Biofilm scour to provide food for aquatic macroinvertebrates. 	<ol style="list-style-type: none"> 1. Morphological criteria based on benches. 2. Morphological criteria based on transect features. 3. No specific criterion (but freshes required). 4. Stream power capable of moving cobbles in the Don River ($\tau_c > 45 \text{ N/m}^2$). 5. Stream power capable of moving cobbles in the Don River ($\tau_c > 45 \text{ N/m}^2$). 6. Stream power during fresh capable of disturbing sand bars ($\tau_c > 15 \text{ N/m}^2$). 7. Stream power during fresh capable of disturbing sand bars ($\tau_c > 15 \text{ N/m}^2$). 8. Bed shear stress during fresh capable of moving silt ($\tau_c > 15 \text{ N/m}^2$). 9. No known criterion (other scour criteria considered adequate).

A number of benches were identified in the Don River transects including low channel benches (Figure 4.11) as well as a major in-channel bar (Figure 4.12). A flow of 45 ML/d was identified as suitable to

inundate all of the low benches (Figure 4.11) and 80 ML/d was required to inundate the in-channel bench and fill the side channel (Figure 4.12).

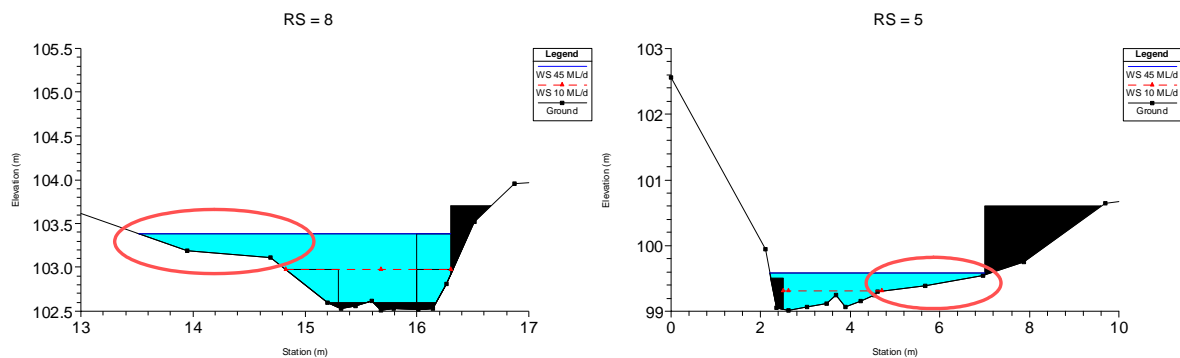


Figure 4.11 Channel detail with examples of low channel benches identified in the Don River and flows of 45 ML/d (filled) and the cease to divert flow of 10 ML/d (red dotted).

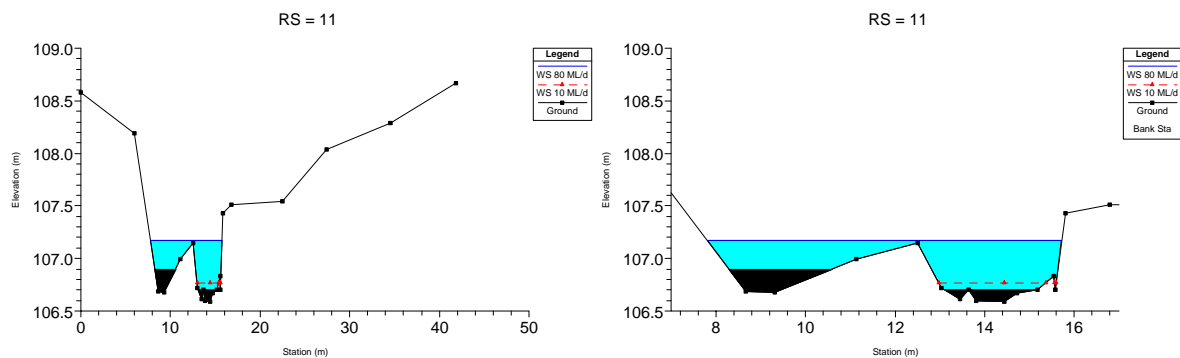


Figure 4.12 Channel detail of transect with in-channel bench (full transect left, detail right) at flows of 80 ML/d and the cease to divert flow of 10 ML/d.

The flows of 45 and 80 ML/d satisfies all other assessment criteria for channel scour and disturbance. Shear values for the riffle transects at a flow of 45 ML/d are between 41 and 239 N/m² (with 9 of the 10 riffle transects having shear values over 45 N/m²). In the two pools, shear values at 45 ML/d are below 45 N/m², but higher than the 15 N/m² required to move silt from the bed.

Shear values for the pool transects at a flow of 80 ML/d are higher than 45 N/m². These indicative values suggest that the two High Flow Fresh flows that inundate the benches should be adequate for in-channel disturbance functions from Table 4.15.

Although no specific criteria can be set for determining flows suitable as cues for fish breeding and migration, it is assumed that a flow of 45 ML/d represents a sufficient change from baseflow to initiate these events. One additional requirement for fish breeding and migration cues is that the first such flow in the Transitional or early High Flow Season (June to August) needs to be preserved to provide spawning/migration cues as early as possible.

Flows of 45 ML/d or more naturally occurred between 1970-1987 at the streamflow gauge in the Don River at a median frequency of 2.5 times a year, each spell occurring at a median duration of 1 days⁵.

Flows of 80 ML/d or more naturally occurred between 1970-1987 at the streamflow gauge in the Don River at least once in 8 years out of 17 years (rounded up to 1 in 3 years⁶), each spell occurring at a median duration of 1 day.

None of the flow-related processes associated with High Flow Freshes (Table 4.15) would indicate an appropriate independence value. An arbitrary independence value of 14 days was selected for the 200 ML/d flow, in part to provide for a series of fish breeding/migration cues, especially over the early part of the June to November period.

High Flow Fresh recommendation for the Don River:

- ✱ **Flow: 45 ML/d, 2.5 per year, 1 day duration;**
- ✱ **Timing: June to December inclusive;**
- ✱ **First High Flow Fresh between June and August to be preserved;**
- ✱ **Independence: 14 days**

High Flow Fresh recommendation for the Don River:

- ✱ **Flow: 80 ML/d, 1 in 3 years, 1 day duration;**
- ✱ **Timing: June to December inclusive;**

Bankfull and Overbank Flows

Bankfull Flows fill the channel, but do not spill onto the floodplain. They have mainly geomorphological functions, maintaining the channel shape and form (Table 4.16). Overbank flows are higher than the bankfull flows, and spill out of the channel onto the floodplain. These are ecologically important for stream associated wetlands, for recruiting carbon into the river system (dissolved from the floodplain floor, or in the form of organic debris) or woody debris from the floodplain to the stream channel, and for disturbing the riparian vegetation (Table 4.16).

Table 4.16 Flow-related processes and assessment criteria for Bankfull and Overbank Flows in the Don River

Flow Component	Flow-related process	Assessment criteria
Bankfull and overbank Flows	<ol style="list-style-type: none"> 1. Inundate floodplain to deliver carbon and woody debris to the stream; 2. Bench inundation to deliver carbon to the stream; 3. Maintain channel form and key habitats, including in-channel benches; 4. Maintain channels and inlets for connectivity of main channel with important floodplain and wetland zones; 5. Disturb riparian vegetation to provide new habitats and regeneration. 	All – Morphological criteria based on transect features for bankfull

⁵ By comparison, if the modelled data was used, the frequency would be 1 per year with a duration of 5 days.

⁶ The recommendation is rounded up rather than down to 1 in 2 years, because if the current flow had the same frequency as the natural flow, it would not technically be in compliance with a 1 in 2 year frequency.

Determining a specific bankfull flow in the Don River is difficult as the steep nature of the valley means that the floodplain is a network of stepped extended benches, rather than a traditional extensive single floodplain. A flow of 100 ML/d was sufficient to just inundate the largest of these benches (Figure 4.13) and was selected as the Bankfull and Overbank flow recommendation.

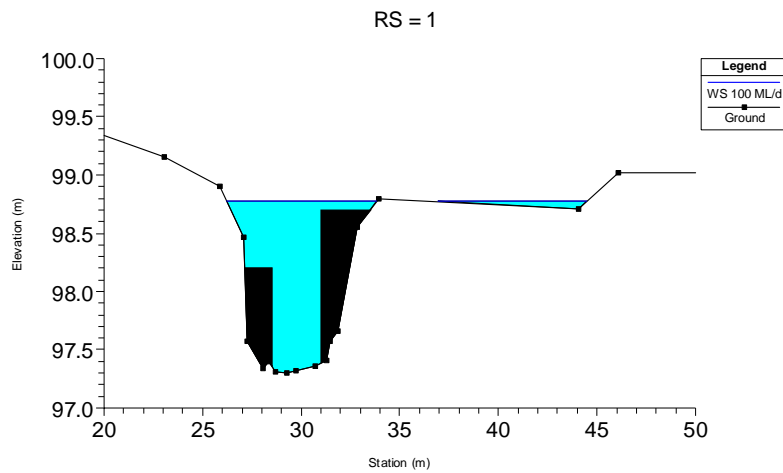


Figure 4.13 Largest floodplain bench in the Don River with a flow of 100 ML/d

Flows of 100 ML/d or more naturally occurred between 1970-1987 at the streamflow gauge in the Don River at least once in 4 years out of 17 years (rounded to 1 in 5 years), each spell occurring at a median duration of 1 day.

Bankfull and Overbank Flow recommendation for the Don River:

- ✱ **Flow: 100 ML/d, 1 in 5 years, 1 day**
- ✱ **Timing: Any time**

Summary of environmental flow recommendations for the Don River

Table 4.17 Summary of environmental flow recommendations in the Don River.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low Flow Season					High Flow Season						
Cease to Divert Flow: 3 ML/d					Cease to Divert Flow: 10 ML/d						
Low Flow Fresh: 10 ML/d, 3 per year, 9 days					High Flow Fresh: 45 ML/d, 2 per year, 1 day						
					High Flow Fresh: 80 ML/d, 1 in 3 years, 1 day						
Bankfull and Overbank Flow: 100 ML/d, 1 in 5 years, 1 day											

Achievement of environmental flow recommendations for the Don River

The recommended flows in the summary table above were compared with the current flows modelled for the Little Yarra River (Table 4.18). It is important to note that the modelling of current flows do not include any interim flow management arrangements and assume no environmental flow rules are in operation.

The recommended cease to divert flows are not achieved in the Don River, as lower flows are currently recorded more frequently than under natural conditions. The inclusion of a cease to divert

flow of 3 ML/d between January and May, and a cease to divert flow of 10 ML/d between June and December in the Don River Streamflow Management Plan would ensure that this recommendation was met.

Low Flow Fresh recommendations are achieved at the current level of development, and all of the High Flow Fresh and Bankfull and Overbank Flow recommendations are likely to be achieved at the current level of development.

Table 4.18 Achievement table for environmental flow recommendations in the Don River

Season	Recommendation	Current	Achievement
Jan - May	Cease to Divert flow 3 ML/d	Naturally lower than 3 ML/d, 73 times in 41 years, 5 days Currently lower than 3 ML/d, 103 times in 41 years, 6 days	Not achieved, lower flows too frequent and long
Jan - May	Low Flow Freshes: >10 ML/d, 3 per year, 9 days	Currently 3 per year, 9 day median.	Achieved
Jun - Dec	Cease to Divert flow 10 ML/d	Naturally lower than 10 ML/d, 170 times in 41 years, 5 days Currently lower than 10 ML/d, 186 times in 41 years, 5 days	Not achieved, lower flows too frequent
Jun - Dec	High Flow Freshes: >45 ML/d, 2 per year, 1 day	Unknown, but likely to be met due to low diversion rate*	Achieved
Jun - Dec	High Flow Freshes: >80 ML/d, 1 in 3 years, 1 day	Unknown, but likely to be met due to low diversion rate	Achieved
All year	Bankfull Flows: >100 ML/d, 1 in 5 years, 1 day	Unknown, but likely to be met due to low diversion rate	Achieved

* - no current frequency or duration is presented as the modelled flows are not thought to represent actual flows at these high flow rates.

Supporting Recommendations

Flow Management

- No streamflow gauge is currently operative in the Don River for managing flows, or measuring compliance with flow requirements determined through the SFMP. The old gauge located upstream in the Don River (should it still be useable) may be suitable for implementing diversion bans (i.e. determining cease to divert conditions), but could not be used for reporting on compliance with any flow requirements. A new gauge (or other flow monitoring device) will be required for compliance reporting.
- The new gauging station will need to be located downstream of the majority of diversions in the valley, but upstream of any possible influence of high flows from the Yarra River. No definitive recommendation on a location for the gauge can be made, but it is suggested that the general location should be around Dalry Road.

Large Woody Debris Management

- The presence of deeper areas in the Don River is almost exclusively driven by the presence of Large Woody Debris (LWD) and associated organic material (leaves and twigs). Removal of LWD should be prevented, unless otherwise demonstrated as a serious threat to a high value asset or human life.
- Riparian vegetation provides the major source of Large Woody Debris to the channel. LWD encourages diversity in the bed form and variation in water depth for in-stream habitat, and reduces the energy of the flow leading to a reduction in bank erosion. Riparian stands providing potential future sources of LWD should be maintained or regenerated.

Riparian Vegetation Management

- Riparian and floodplain vegetation has been widely cleared and/or grossly modified in sections of the Don River. Riparian Forest, Riparian Scrub, Swampy Riparian Complex and Damp Heathy Woodland EVCs have been extensively cleared throughout southern Victoria. The restoration of riparian and some floodplain vegetation in cleared areas should be a long term objective.
- Riparian vegetation also forms an important food source for the food chain in the Don River. Restoring riparian vegetation, where it is disturbed or absent, will improve the conditions of the food chain in the river.
- Willow trees appear to be relatively rare in the Don River. However, willows have the ability to spread rapidly, and small infestations should be managed or removed before they become a major problem.
- Numerous serious environmental weed species were noted during the field investigation. There is currently no evidence of weed control effort on either public or private land. Weed management is urgently required to maintain the significant vegetation values and natural stream forms along the river and to prevent or impede the further spread into as yet un-invaded areas.

Stock Management

- Direct trampling and disturbance from unrestricted stock access leads to increased erosion and channel change through the removal of stabilising ground and understorey cover of riparian vegetation, and the creation of flow pathways for sediment transfer. Stock access to streams should be minimised or curtailed through fencing of the riparian zone. This includes fencing of wetland or boggy areas adjacent to the Don River.

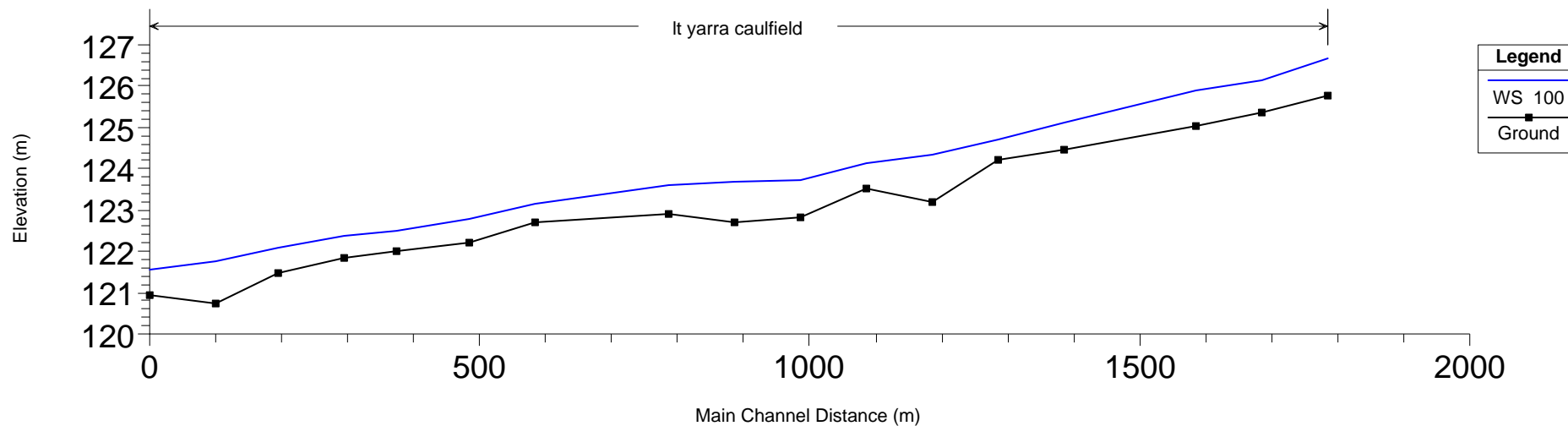
Water Quality Management

- A high level of water quality needs to be maintained to protect and enhance in-stream environments. Total nitrogen was observed to be over SEPP requirements in the Don River in the Don River in 2001 (Crowther *et al.*, 2001). The Technical Panel believes that flow manipulation (i.e. providing dilution flows) to address water quality issues is an inappropriate use of a valuable water resource, and such water quality problems should be tackled and managed at their source.
- Sources of excess sedimentation (such as from un-made road crossings or eroding banks) need to be reduced wherever they occur.

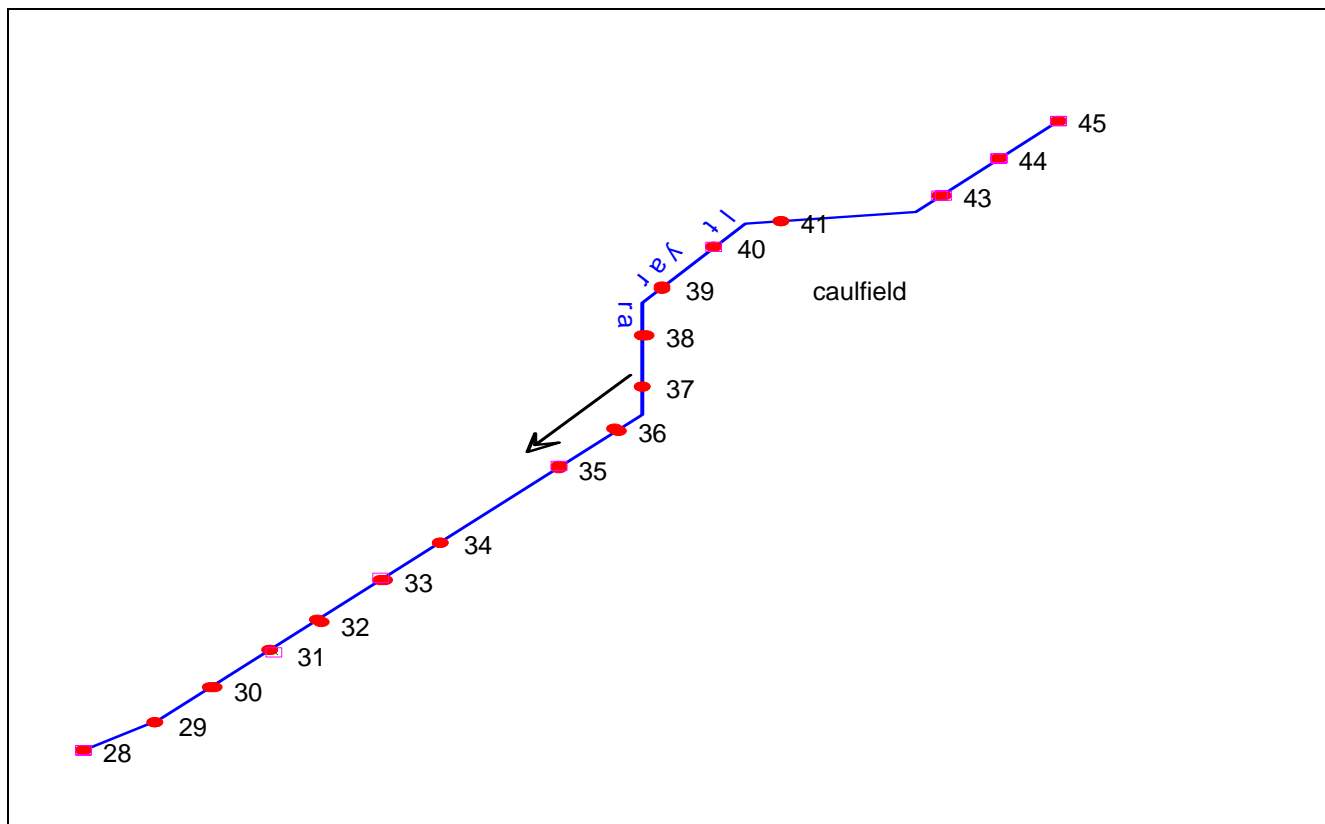
5. References

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- Crowther, D., Canale, G., Nicol, M., Papas, P. and McKay, S. (2001) *Melbourne Water Biological Monitoring Program 2000/2001*. Unpublished Report by Arthur Rylah Institute for Environmental Research, to Melbourne Water Corporation, Melbourne.
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Appendix 1 Profiles and Transects in the Little Yarra River

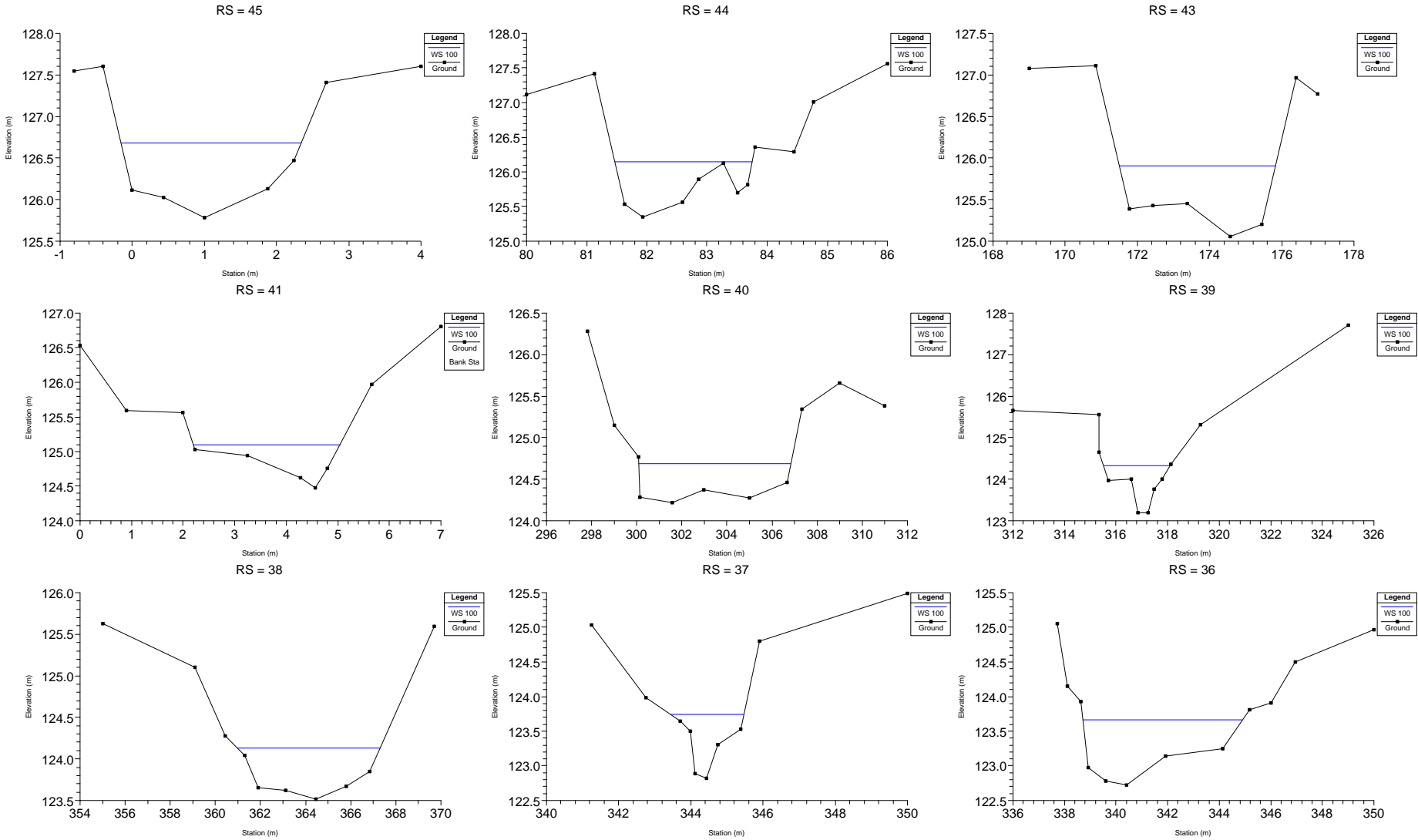


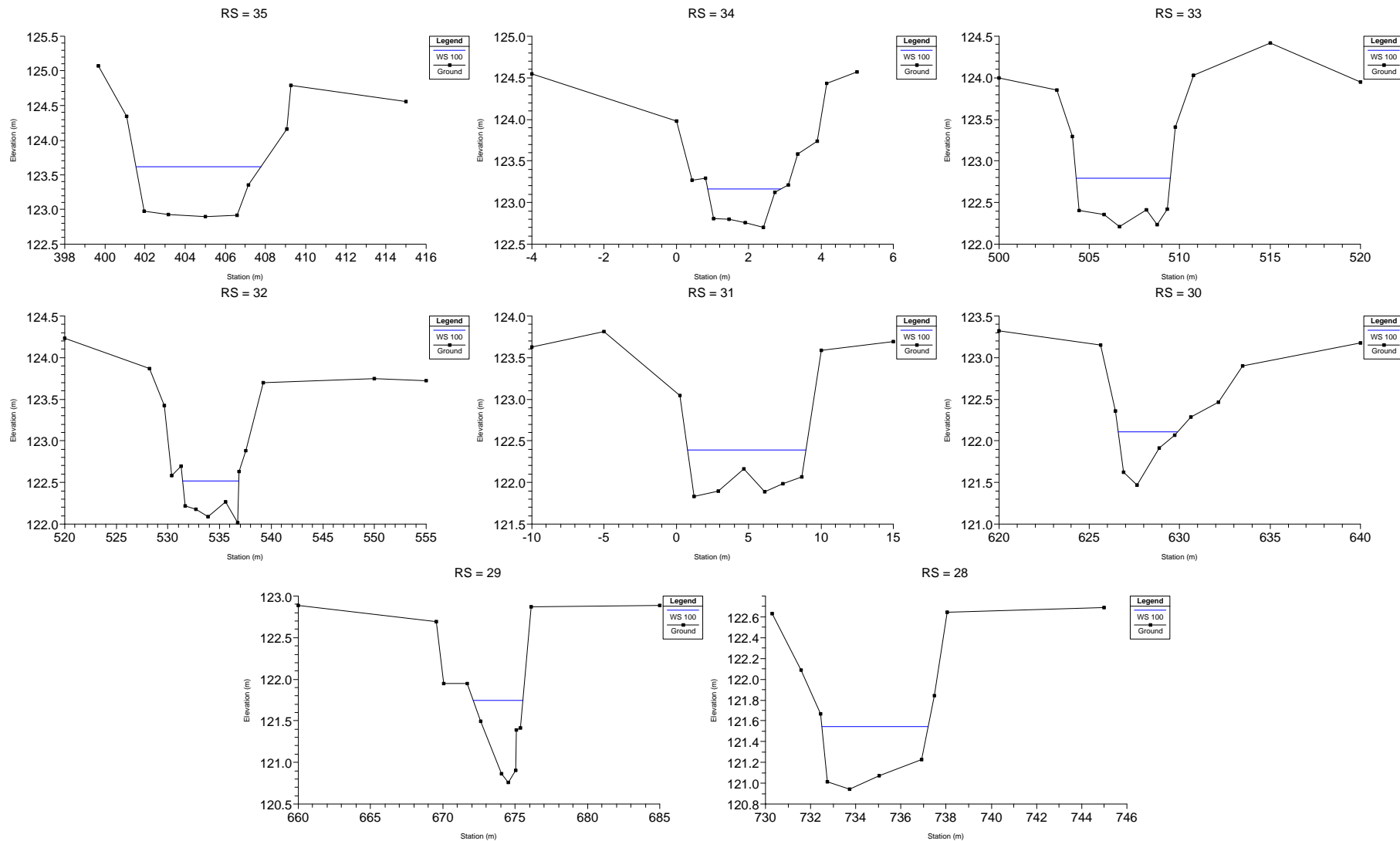
Long Profile of Little Yarra River transects



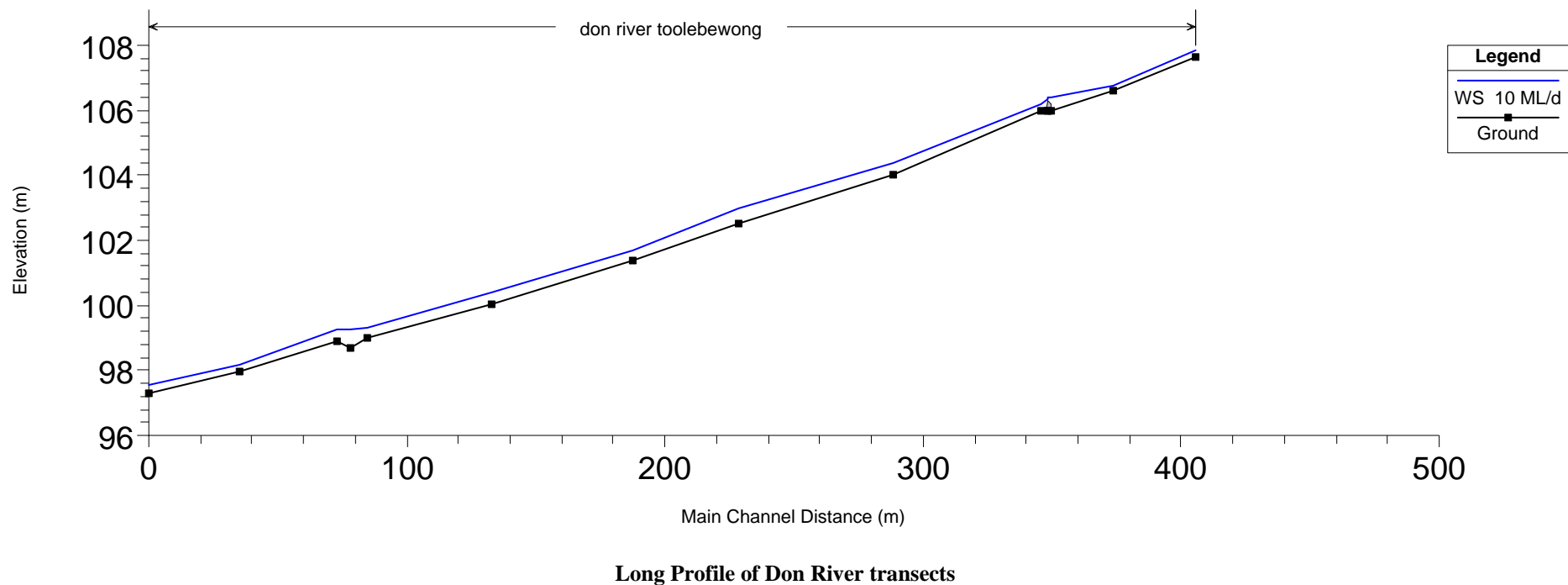
Layout and relationship between Little Yarra River transects

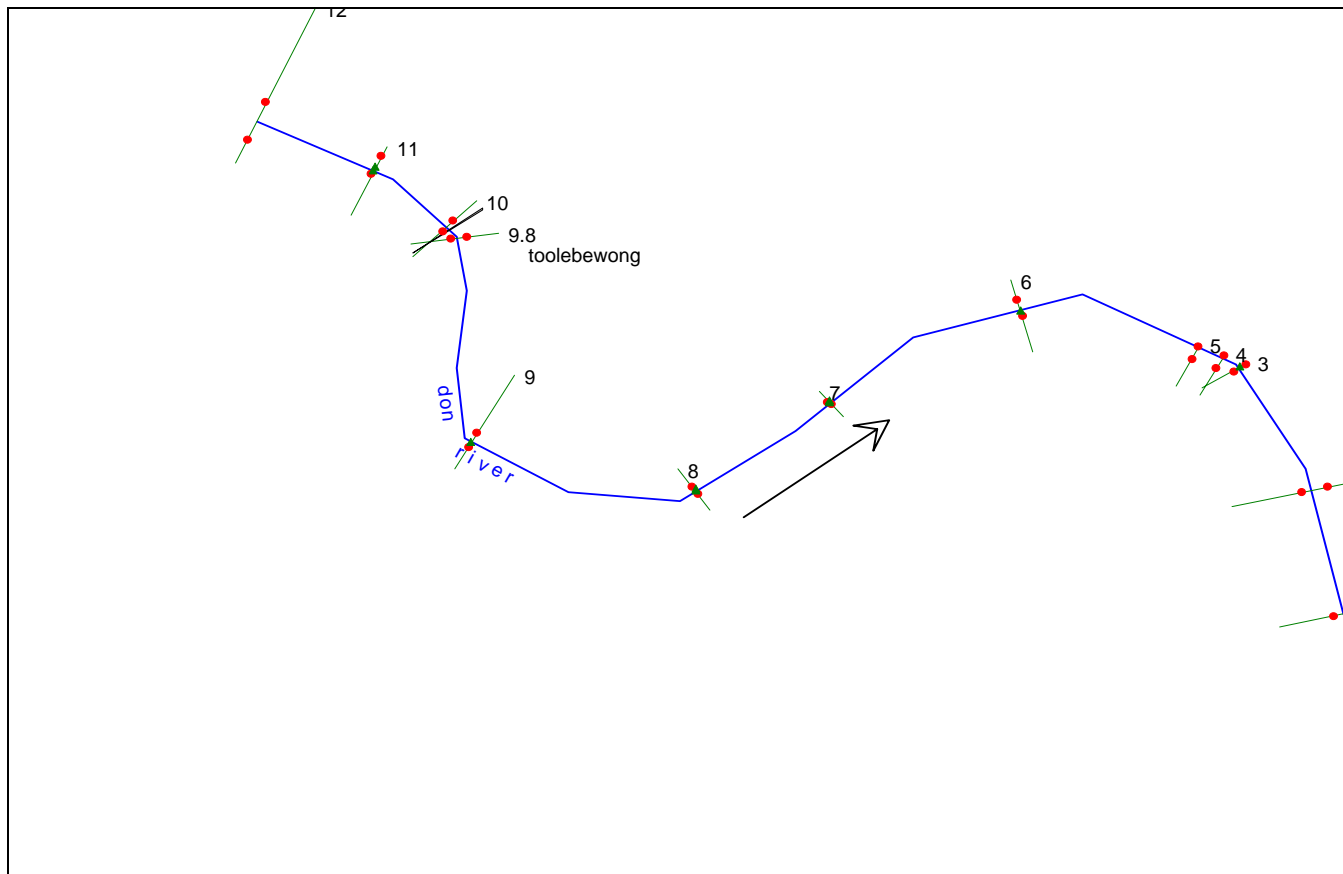
Individual transects in the Little Yarra River (starting upstream) – flow shown at 100 ML/d.





Appendix 2. Profiles and transects in the Don River





Layout and relationship between Don River transects

Individual transects in the Don River (starting upstream) – flow shown at 10 ML/d.

