# Management Flows for Aquatic Ecosystems in Twelve Mile Creek

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# Overview

## Background

Twelve Mile Creek is a tributary of Lake Wakatipu and drains a small, steep mountainous catchment at the southern end of the Richardson Mountains, near Queenstown.

### *Why was this study done?*

This report is intended to inform the setting of a minimum flow or residual flows for the Twelve Mile Creek catchment. It considers the following:

- The hydrology and existing water allocation in the Twelve Mile Creek.
- The aquatic values of the Twelve Mile Creek.
- The flows that will maintain aquatic ecological values in Twelve Mile Creek.

### *What did this study find?*

- Twelve Mile Creek provides spawning habitat for brown and rainbow trout and it is likely that it contributes to recruitment to the nationally significant trout fishery in Lake Wakatipu. It provides limited angling for resident adult trout, although the delta where Twelve Mile Creek enters Lake Wakatipu is a popular area for angling.
- Upland bully and koaro have been recorded from Twelve Mile Creek. Koaro are classified as “declining”, while upland bully are classified as “not threatened”.
- Existing allocation in the Twelve Mile Creek catchment is very low (6.61 l/s) and is, therefore, unlikely to be having any impact on aquatic life.
- In-stream habitat modelling was conducted to determine how changes in flow affect habitat for the fish species present in Twelve Mile Creek. The flows recommended to maintain fish habitat in Twelve Mile Creek are summarised in the table below:

| Months | 7-d MALF (l/s) | Recommended flow (l/s) | Reason |
|---|---|---|---|
| **December-April** | 135 | 105 | Juvenile trout, koaro, adult trout habitat |
| **May-November** | | 120 | Trout spawning habitat |

- The results of this investigation will be used to inform assessments of residual flows on future applications to take water from the Twelve Mile Creek catchment and ultimately any future minimum flow.

# Technical summary

Twelve Mile Creek is a tributary of Lake Wakatipu and drains a small, steep mountainous catchment at the southern end of the Richardson Mountains, near Queenstown. Most of the Twelve Mile Creek catchment is dominated by indigenous vegetation and water allocation is currently low, although there is the potential for future development in the vicinity, with the Twelve Mile Creek catchment being a likely water supply for such development.

The objectives of this report were to:

- Present information on the Twelve Mile Creek that is relevant to determining the flows required to sustain the river's aquatic habitat including freshwater values, flow statistics and the distribution of water resources within the catchment in addition to the results of in-stream habitat modelling.
- Assess the aquatic values of Twelve Mile Creek.
- To present and interpret the results of analysis to recommend flows required to maintain aquatic ecological values.

Twelve Mile Creek provides spawning habitat for trout and it is likely that it contributes to recruitment to the nationally significant trout fishery in Lake Wakatipu. It provides limited angling for resident adult trout, although the delta where Twelve Mile Creek enters Lake Wakatipu is a popular area for angling. Upland bully and koaro have been recorded from Twelve Mile Creek in addition to both rainbow and brown trout. Koaro are classified as "declining" in the most recent assessment of the conservation status of New Zealand freshwater Fish, while upland bully were classified as "not threatened" (Goodman et al. 2014).

Existing allocation in the Twelve Mile Creek catchment is very low (combined maximum instantaneous rate = 6.61 l/s) and is, therefore, unlikely to be having any impact on aquatic life.

The flows recommended to maintain fish habitat in Twelve Mile Creek are presented in the table below:

| Months | 7-d MALF (l/s) | Recommended flow (l/s) | Reason |
|---|---|---|---|
| **December-April** | 135 | 105 | Juvenile trout, koaro, adult trout habitat |
| **May-November** | | 120 | Trout spawning habitat |

The results of this investigation will inform assessments of a minimum flow or residual flows on future applications to take water from the Twelve Mile Creek catchment.

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# 1 Introduction

The Regional Plan: Water for Otago (2013; Water Plan) sets out as one of its objectives 'to retain flows in rivers sufficient to maintain their life-supporting capacity for aquatic ecosystems and their natural character[1]. As a means of achieving this objective, the Water Plan provides for the setting of minimum flows in Otago's rivers[2].

Twelve Mile Creek is a tributary of Lake Wakatipu and drains a small, steep mountainous catchment at the southern end of the Richardson Mountains (Figure 2.1, Figure 2.2). Most of the catchment is Crown land and is administered by the Department of Conservation and is covered by indigenous vegetation. Water allocation is currently low but there is the potential for future development in the vicinity, with the Twelve Mile Creek catchment being a likely water supply for such development.

Schedule 1A of the Water Plan[3] identifies the ecosystem values that must be sustained in Otago catchments. In Twelve Mile Creek, these include spawning and juvenile rearing habitat for trout. Further to these values, Twelve Mile Creek also supports populations of koaro, which is listed as declining in the most recent review of the conservation status of New Zealand freshwater fish (Goodman *et al.* 2014).

## 1.1 Objectives

This report presents information on Twelve Mile Creek that is relevant to determining the flows required to sustain the river's aquatic habitat. This includes freshwater values, flow statistics and the distribution of water resources within the catchment in addition to the results of in-stream habitat modelling.

[1] [1] Objective 6.3.1 of the Regional Plan: Water for Otago (2013), p. 6–7
[2] Policies 6.4.1 – 6.4.11 of the Regional Plan: Water for Otago (2013), pp 6–13 to pp 6–26
[3] Schedule 1A of the Regional Plan: Water for Otago (2013), p. 20–6

**Figure 2.1** **Twelve Mile Creek approximately 150 m upstream of the Glenorchy-Queenstown Road.**

**Figure 2.2** **Electric fishing in Twelve Mile Creek near Lake Wakatipu in March 2005. The flow at the site of the flow recorder used in this study was estimated to be 410 l/s.**

# 2 The Twelve Mile Creek catchment

Twelve Mile Creek drains a steep, small (25.2 km$^2$) catchment at the southern end of the Richardson Mountains, approximately 7.5 km west of Queenstown (Figure 2.3). The upper reaches of Twelve Mile Creek drains the alpine Lake Isobel (approx. 1590 m a.s.l) and flows for 8 km before entering Lake Wakatipu (310 m a.s.l.) at the western edge of Wilson Bay (Figure 2.3).


**Figure 2.3** **The Twelve Mile Creek catchment showing the location of the hydrological monitoring site.**

## 2.1 Vegetation & land use

Much of the Twelve Mile Creek catchment (98%) is Crown land and is administered by the Department of Conservation. As a consequence, much of the vegetation in the catchment is unmodified or is recovering from previous landuse activities. The upper catchment is dominated by tall tussock, alpine/subalpine vegetation and areas of bare rock and gravel, while the lower catchment is dominated by native forest and a mix of manuka/kanuka scrub (Figure 2.4, Table 2.1). Only a very small area of the catchment consists of pastoral grassland (Figure 2.4, Table 2.1).

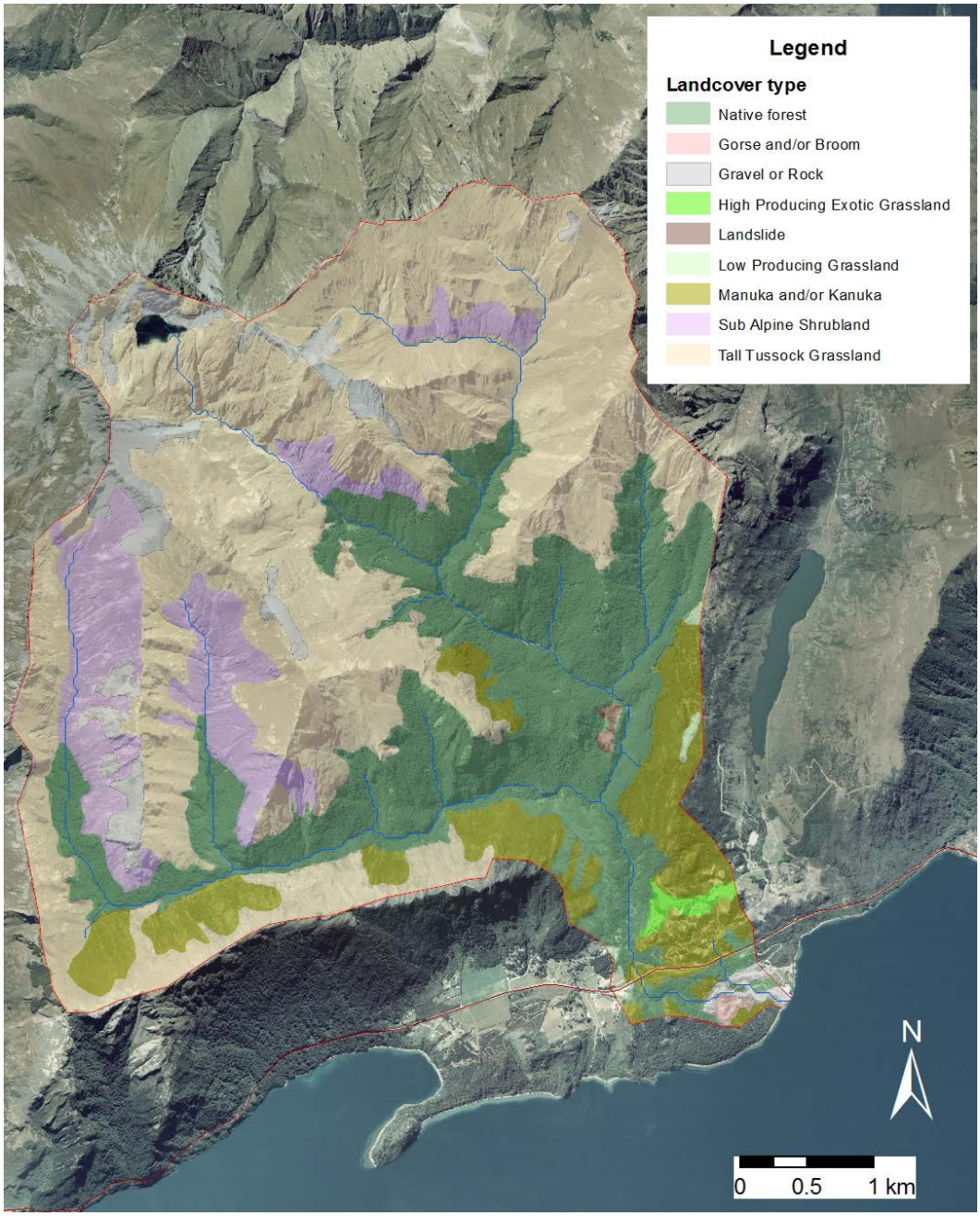


**Figure 2.4** **Landcover in the Twelve Mile Creek catchment. Based on land cover database (Version 4).**

**Table 2.1** **Land cover types in the Twelve Mile Creek based on the Land Cover Database version 4 (LCDBv.4).**

| Landcover type | Area (ha) | % cover |
|---|---|---|
| Alpine and subalpine vegetation | 246 | 10% |
| Tall tussock grassland | 1206 | 48% |
| Native forest | 681 | 27% |
| Manuka and/or kanuka | 232 | 9% |
| Pasture grassland | 17 | 1% |
| Gravel or rock | 129 | 5% |
| Other | 17 | 1% |

## 2.2 Rainfall and flow patterns in the Twelve Mile Creek catchment

### 2.2.1 Rainfall patterns

The annual median rainfall in the Twelve Mile Creek catchment ranges from 1000 mm in the lower catchment up to in excess of 2100 mm in the upper catchment (Figure 2.5).

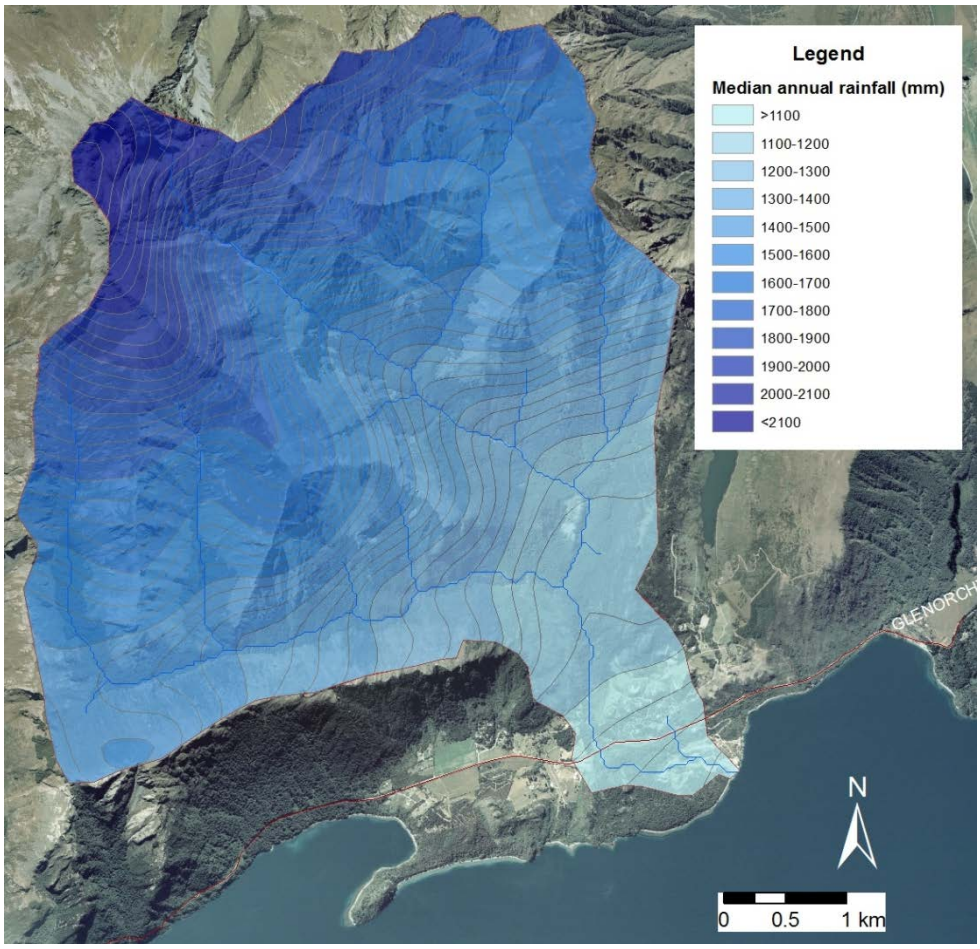


**Figure 2.5** **Median annual rainfall over the Twelve Mile Creek catchment (from Grow Otago).**

## 2.3 River hydrology

### 2.3.1 Hydrological comparison of Twelve Mile Creek with the Upper Shotover River

Flows in Twelve Mile Creek were measured at a temporary flow monitoring site (Figure 2.3) between 11 October 2013 and 8 September 2014. The purpose of this temporary flow site was to establish a flow record for comparison with another nearby permanent flow site to estimate flow statistics for the Twelve Mile Creek catchment. The flow site chosen for this comparison is the Shotover at Peat's Hut. The Twelve Mile Creek catchment is much smaller, lower altitude and receives less rainfall than the upper Shotover catchment (Table 2.2).

**Table 2.2** **Comparison of characteristics between Twelve Mile Creek and Shotover (at Peat's Hut) catchments**

| | Twelve Mile Creek | Shotover at Peat's Hut |
|---|---|---|
| Catchment area ($km^2$) | 25.2 | 611.3 |
| Elevation (m) | 310-1873 | 460-2525 |
| Lake (% of catchment) | 0.2 | 0.5 |
| Rainfall (mm) | 1025-2150 | 1025-4475 |

Despite the apparent differences between these two catchments, comparison of flows in the upper Shotover River and the corresponding flows in Twelve Mile Creek shows a power relationship between these sites (Figure 2.6, regression: $F_{2,135}$=759.4, $R^2$=69.7%, $P$<0.0001). The relationship between flows at these two sites is:

$$Q_{Twelve\ Mile} = 0.0057 \times Q_{Peats\ Hut}^{1.4479}$$

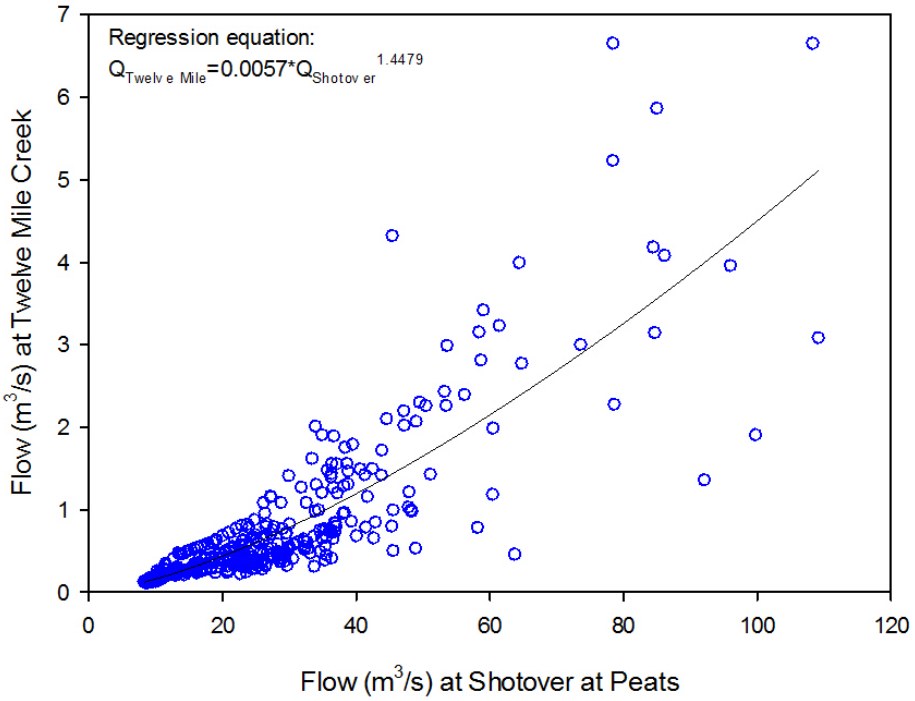


**Figure 2.6** **Relationship between flows in the upper Shotover and flows in Twelve Mile Creek between 12 October 2013 and 8 September 2014.**

### 2.3.2 Estimated flow statistics for Twelve Mile Creek

Flow statistics for Twelve Mile Creek were estimated from the corresponding flow statistic for the Shotover River at Peat's Hut using the regression equation presented in Section 2.3.1. These flow statistics are presented in Table 2.3.

**Table 2.3** **Flow statistics for the Shotover River at Peat's Hut based on (10 complete hydrological years of data; 11-Dec-1996 – 25-Jul-2014) and estimated flow statistics calculated based on the relationship in Figure 2.6.. MALF = mean annual low flow.**

| Site | Mean flow (l/s) | Median flow (l/s) | 7-day MALF (l/s) | Catchment area (ha) | Catchment yield at MALF (l/s/ha) |
|---|---|---|---|---|---|
| Shotover at Peat's Hut | 25,007 | 19,248 | 8,880 | 61,125 | 0.145 |
| **Twelve Mile Creek*** | **603** | **413** | **135** | **2,528** | **0.053** |

The estimated 7-day mean annual low flow (MALF) for Twelve Mile Creek is 135 l/s (Table 2.3, 95% confidence interval: 122-145 l/s). The 7-day average flow in the upper Shotover River dropped below the 7-day mean annual low flow between the 1 and 2 April 2014 (7-day average flows: 8,903 l/s and 8,722 l/s, respectively). The corresponding 7-day average flows in Twelve Mile Creek were 108 l/s and 107 l/s.

# 3 Water allocation

There are three permits for water takes within the Twelve Mile Creek catchment, with a combined maximum instantaneous rate of 6.61 l/s (Table 3.1). All three are groundwater takes in the vicinity of the Glenorchy-Queenstown Road crossing and all are within 100 m of Twelve Mile Creek (Figure 3.1). Because of this, all three are treated as primary surface water allocation.

**Table 3.1 Consented consumptive water takes in the Twelve Mile Creek catchment.**

| Consent | Consent type | Max. instantaneous rate (l/s) | Max. daily take (l/s) | Max. annual take (l/s) | Activity |
|---|---|---|---|---|---|
| 2000.462 | Groundwater take permit | 4 | 208 | 18,720 | Irrigation, communal domestic water supply, mining |
| 2004.633 | Groundwater take permit | 1.21 | 75.5 | 27,633 | Communal domestic water supply |
| 2005.666 | Groundwater take permit | 1.4 | 56 | 11,928 | Communal domestic water supply, irrigation |

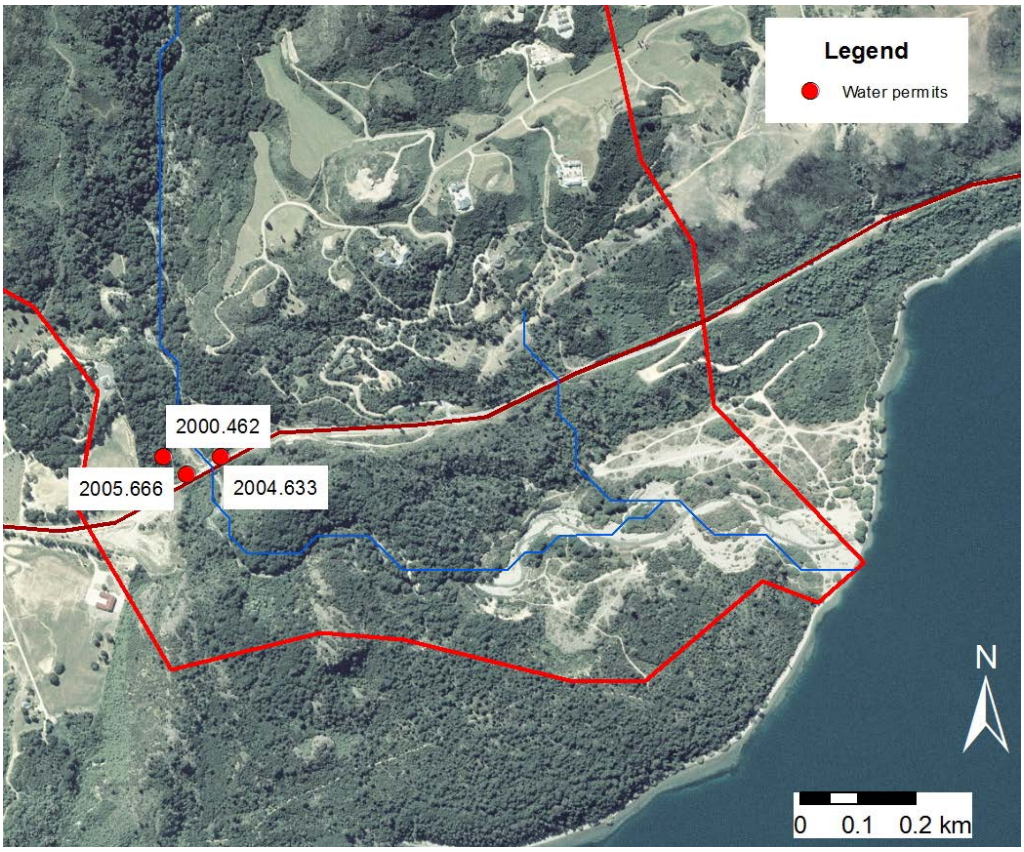


**Figure 3.1 Consented surface water and groundwater takes in the Twelve Mile Creek catchment**

# 4 Values of the Twelve Mile Creek catchment

## 4.1 Freshwater fish

Four fish species have been recorded from Twelve Mile Creek; brown trout, rainbow trout, koaro and upland bully (Table 4.1, Figure 4.1). Koaro was classified as declining in the most recent threat classification for New Zealand freshwater fish, while upland bully remain classified as "not threatened" (Goodman *et al.* 2014).

Brown trout, rainbow trout and upland bullies have all been recorded from the lower reaches of Twelve Mile Creek, while koaro have been recorded from the lower river as well as from upstream of the Queenstown-Glenorchy Road bridge (Figure 4.1).

**Table 4.1** **Fish species present within the Twelve Mile Creek catchment (Sources: New Zealand Freshwater Fish Database and ORC records). Conservation status is based on Goodman et al. (2014).**

| Common name | Species name | Conservation status |
|---|---|---|
| Brown trout | *Salmo trutta* | Introduced and naturalised |
| Rainbow trout | *Onchorhyncus mykiss* | Introduced and naturalised |
| Koaro | *Galaxias brevipinnis* | Declining |
| Upland bully | *Gobiomorphus breciceps* | Not threatened |

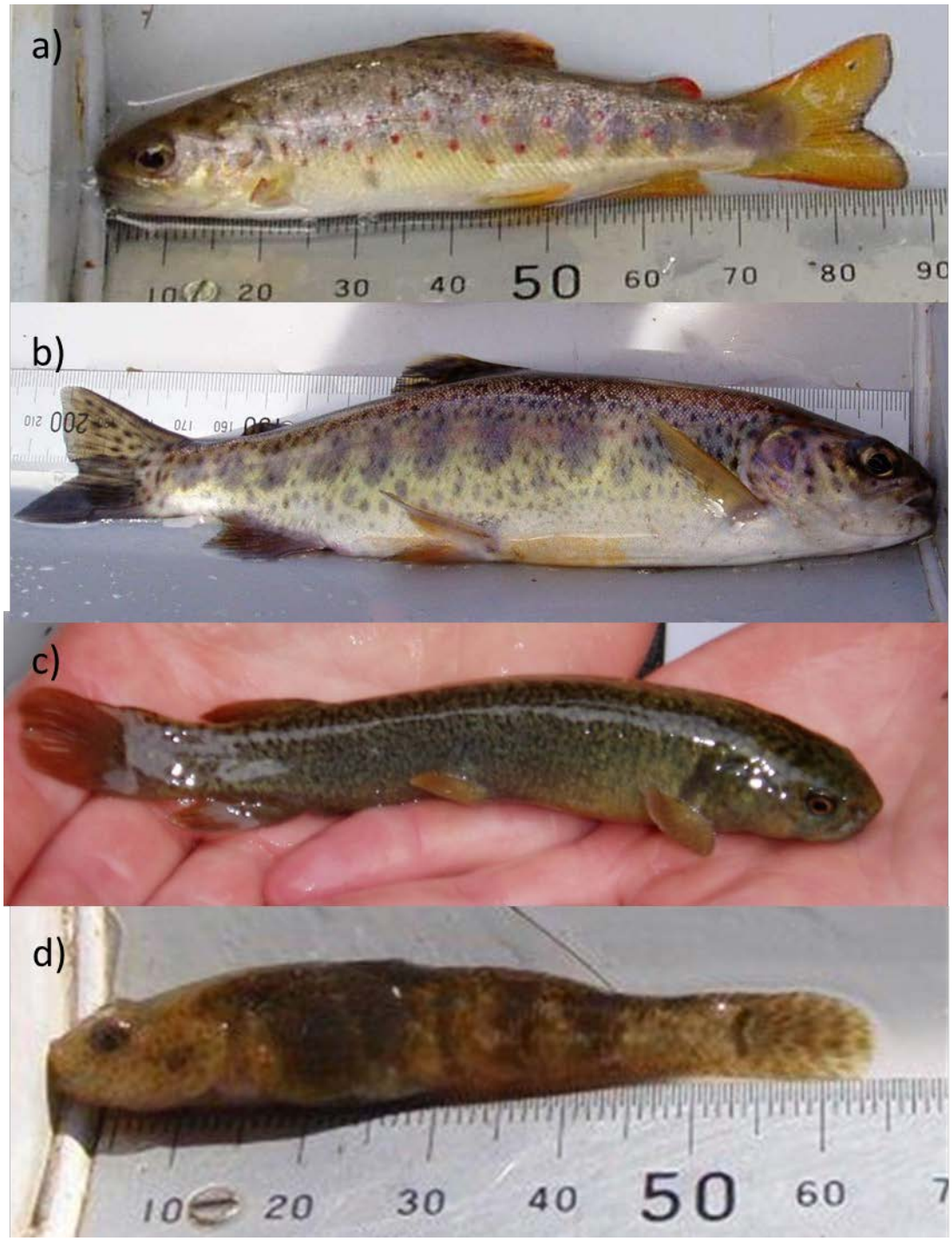


**Figure 4.1** **Fish species recorded from Twelve Mile Creek. a) Brown trout, b) rainbow trout, c) koaro, and d) upland bully.**

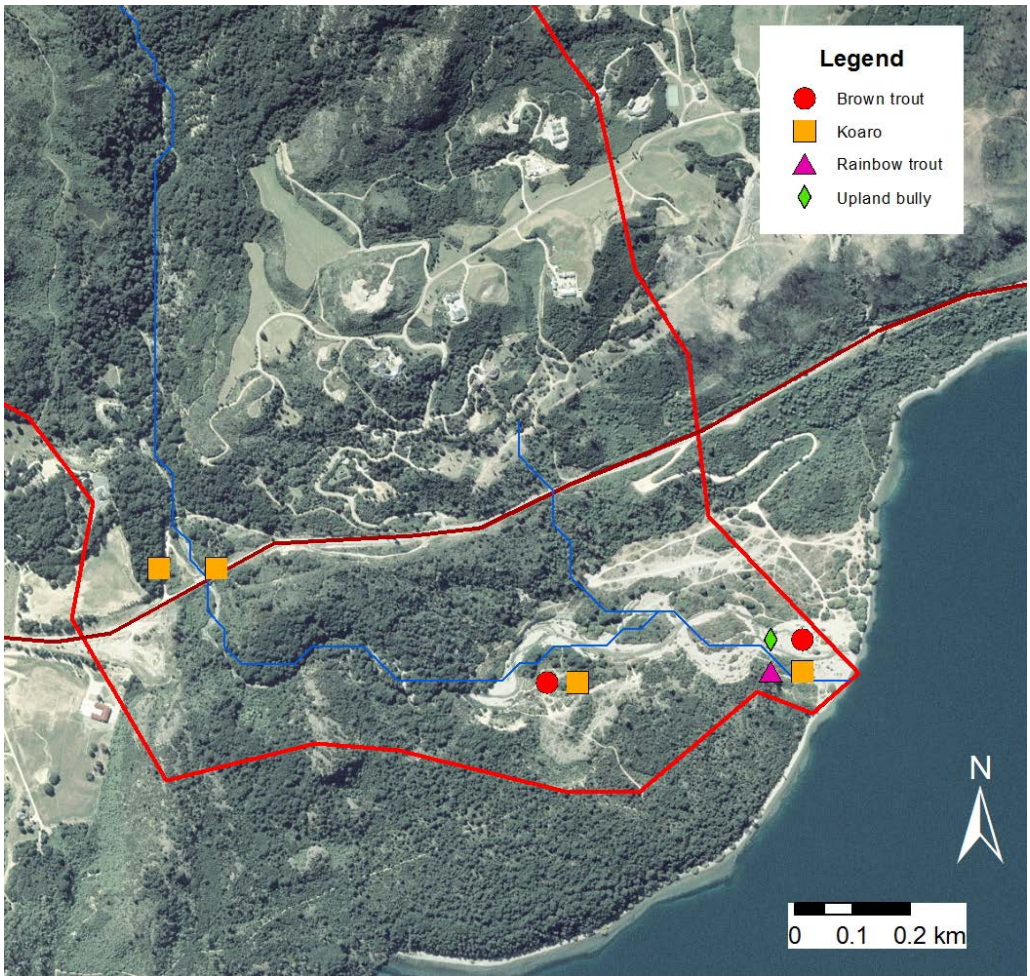


**Figure 4.2** **Distribution of fish species in the lower Twelve Mile Creek catchment based on records from the New Zealand Freshwater Fish Database (April 1999 – April 2001) and electric fishing surveys by Otago Regional Council (17 March 2005).**

## 4.2 Recreational values

The Twelve Mile Creek catchment offers a range of recreational opportunities. There is a campsite offering 100 tent sites at the river delta at the mouth of Twelve Mile Creek with part of the Bob's Cove-Twelve Mile Delta walking track paralleling and crossing Twelve Mile Creek near the campsite. The Mount Crichton Loop track also follows the course of Twelve Mile Creek upstream of the road bridge.

The Twelve Mile Creek delta is a popular fishing spot, with a low level of angler effort being recorded in Twelve Mile Creek in the National Angler Surveys (Table 4.2).

**Table 4.2** **Estimated angler usage in the Twelve Mile Creek catchment from national angler surveys (Unwin 2009).**

| Season | Estimated usage (angler days, ± 1 standard error) |
|---|---|
| 1994/1995 | 20 ± 20 |
| 2001/2002 | - |
| 2007/2008 | 40 ± 40 |

## 4.3 Summary of values

Values assessment is an important part of the flow-setting process and can be used to determine the level of protection required for different values based on their significance within the catchment. Flow-dependent values were assessed for Twelve Mile Creek and appropriate levels of protection were assigned following the approach of Jowett & Hayes (2004). The outcome of these assessments is summarised in Table 4.3.

The trout fishery in Twelve Mile Creek itself is limited (Section 4.2), but there will be some seasonal fishing for adult trout migrating into Twelve Mile Creek for spawning, particularly where Twelve Mile Creek enters Lake Wakatipu. The angling season in Twelve Mile Creek is 1 November to 30 April.

It is likely that spawning in Twelve Mile Creek contributes to recruitment to the nationally significant fishery in Lake Wakatipu (Otago Fish &Game Council 2003), therefore high levels of protection for trout spawning is recommended, with the recommended flows set to protect brown trout spawning and incubation over the period May-August and rainbow trout spawning and incubation over the period September-November (Table 4.3). Similarly, a high level of habitat retention is suggested for juvenile trout (Table 4.3). Given the relatively short length of river used by trout for spawning and the restrictions to upstream migration, it is likely that reductions in juvenile habitat in Twelve Mile Creek resulting from decreasing flow will encourage the out-migration of juvenile trout to Lake Wakatipu.

**Table 4.3 Assessment of instream habitat values at sites in the Twelve Mile Creek River with recommended levels of habitat retention (based on the approach of Jowett & Hayes 2004).**

| Critical value | Fishery or conservation value | Recommended % habitat retention |
|---|---|---|
| Brown trout – adult (seasonal fishery) | Locally significant* | 70 |
| Brown trout – juvenile rearing | Contributes to the nationally significant Lake Wakatipu fishery† | 80 |
| Brown trout – spawning (May-August) | Contributes to the nationally significant Lake Wakatipu fishery† | 80 |
| Rainbow trout – adult (seasonal fishery) | Locally significant* | 70 |
| Rainbow trout – juvenile rearing | Contributes to the nationally significant Lake Wakatipu fishery† | 80 |
| Rainbow trout – spawning (September-November) | Contributes to the nationally significant Lake Wakatipu fishery† | 80 |
| Koaro | Moderate (declining‡) | 70 |
| Upland bully | Low | 60 |

* Based on National Angler Survey results – see Section 4.2.
† Based on the assessment in Otago Fish & Game Council (2003)
‡ Based on Goodman *et al.* (2014)

# 5 Physical habitat survey

The Otago Regional Council contracted the National Institute for Water and Atmospheric research (NIWA) to carry out a study to determine the flows required to maintain acceptable habitat for the fish species present in Twelve Mile Creek. NIWA carried out this work in the section of river between the Glenorchy-Queenstown Road and the confluence of Maori Gully. The in-stream habitat modelling conducted by NIWA (Jowett 2005) forms the basis for most of the analyses presented in this section.

## 5.1 In-stream habitat modelling

In-stream habitat modelling is a means of considering the effects of changes in flow on in-stream values, such as river morphology, physical habitat, water temperature, water quality and sediment processes. As the habitat methods used are based on quantitative biological principles, they are considered more reliable and defensible than assessments made in other ways. The strength of in-stream habitat modelling lies in its ability to quantify the loss of habitat caused by changes in the natural flow regime, which helps to evaluate alternative flow proposals (Jowett, 2005).

Assessing suitable physical habitat for aquatic organisms that live in a river is the aim of in-stream habitat modelling. Habitat methods allow for a more focused flow assessment and can potentially result in improved allocation of resources (Jowett, 2005). However, it is essential to consider all factors that may affect the organism(s) of interest, such as food, shelter and living space, and to select appropriate habitat suitability curves, for an assessment to be credible. Habitat modelling does not take a number of other factors into consideration including biological interactions (such as predation) which can have a significant influence on the distribution of fish species.

## 5.2 Habitat preferences and suitability curves

In-stream habitat modelling requires detailed hydraulic data, as well as knowledge of the ecosystem and the physical requirements of stream biota. The basic premise of habitat methods is that if there is no suitable physical habitat for a given species, then they cannot exist (Jowett, 2005). However, if there is physical habitat available for that species, then it may or may not be present in a survey reach, depending on other factors not directly related to flow, or to flow-related factors that have operated in the past (e.g., floods). In other words, habitat methods can be used to set the outer envelope of suitable living conditions for the target biota (Jowett, 2005).

In-stream habitat is expressed weighted usable area (WUA), a measure of the total area of suitable habitat per metre of stream length. It is expressed as square metres per metre ($m^2/m$).

## 5.3 In-stream habitat modelling for the Twelve Mile Creek

In-stream habitat modelling was undertaken in the reach of Twelve Mile Creek between the Queenstown-Glenorchy Road and the confluence of Maori Gully using the hydraulic and in-stream habitat model RHYHABSIM (Jowett 1989, 2005). Surveys were undertaken at two calibration flows in addition to the initial survey flow (Table 5.1). Jowett (2005) presents more details of the methods employed in these surveys and the results of these analyses.

**Table 5.1** **Survey flows, calibration flows and average physical characteristics in the survey reach of Twelve Mile Creek at the survey flow of instream habitat modelling sites (Jowett 2005).**

| Survey flow (l/s) | Calibration flow 1 (l/s) | Calibration flow 2 (l/s) | Width (m) | Depth (m) | Velocity (m/s) |
|---|---|---|---|---|---|
| 331 | 249 | 171 | 6.1 | 0.2 | 0.26 |

### 5.3.1 Instream habitat

The survey reach in Twelve Mile Creek was dominated by riffles with limited pool habitat (Table 5.2). Coarse substrates dominate the bed of Twelve Mile Creek with boulder, cobble and gravel the most abundant substrate types (Table 5.2).

**Table 5.2** **Habitat characteristics at the three habitat survey sites including meso-habitat types and substrate composition (Jowett 2005).**

| Habitat or substrate type | Twelve Mile Creek |
|---|---|
| Pool (%) | 6 |
| Run (%) | 30 |
| Riffle (%) | 64 |
| Bedrock (%) | 5 |
| Boulder (%) | 24 |
| Cobble (%) | 19 |
| Gravel (%) | 32 |
| Fine gravel (%) | 16 |
| Sand (%) | 6 |

The hydraulic component of in-stream habitat modelling made predictions over how water depth, channel width and water velocity will change with changes in flow (Figure 5.1).

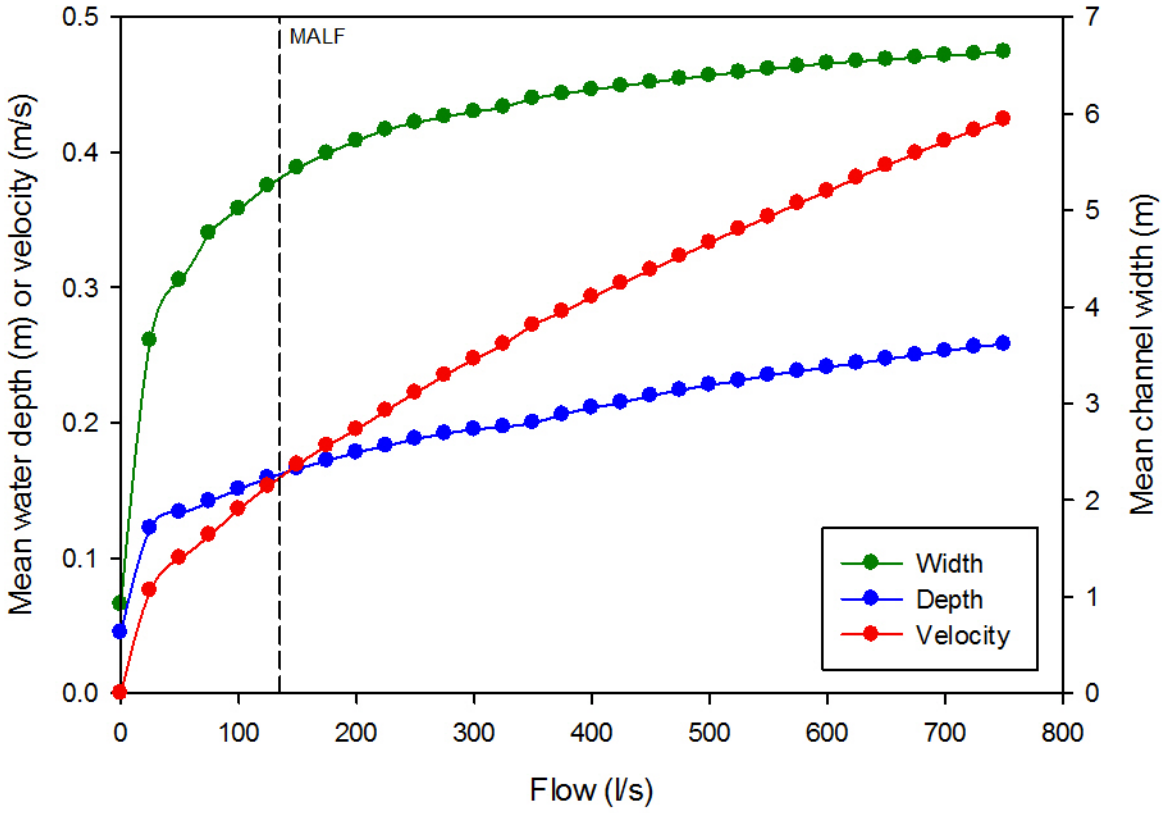


**Figure 5.1** **Changes in mean channel width, mean water depth and mean water velocity with changes in flow in the survey reach of Twelve Mile Creek.**

### 5.3.2 Native fish habitat

Habitat for upland bully increased steeply with increasing flow to an optimum flow of 160 l/s, above which habitat declined (Figure 5.2). Upland bully habitat was predicted to decline rapidly when flows drop below 75 l/s (Figure 5.2, Table 5.3). In contrast, habitat for koaro increased across the modelled flow range (Figure 5.2). In this case, a flow of 96 l/s would maintain 80% of the habitat for koaro available at MALF (Table 5.3). It should be noted that the habitat suitability curves used in this analysis (Richardson & Jowett 1995) were derived in steep cascade habitat in the Onekaka River (Golden Bay) and may not be applicable to the type of habitat present in Twelve Mile Creek, but were included in the absence of other, more appropriate habitat suitability curves for koaro. Therefore, they should be interpreted with caution.

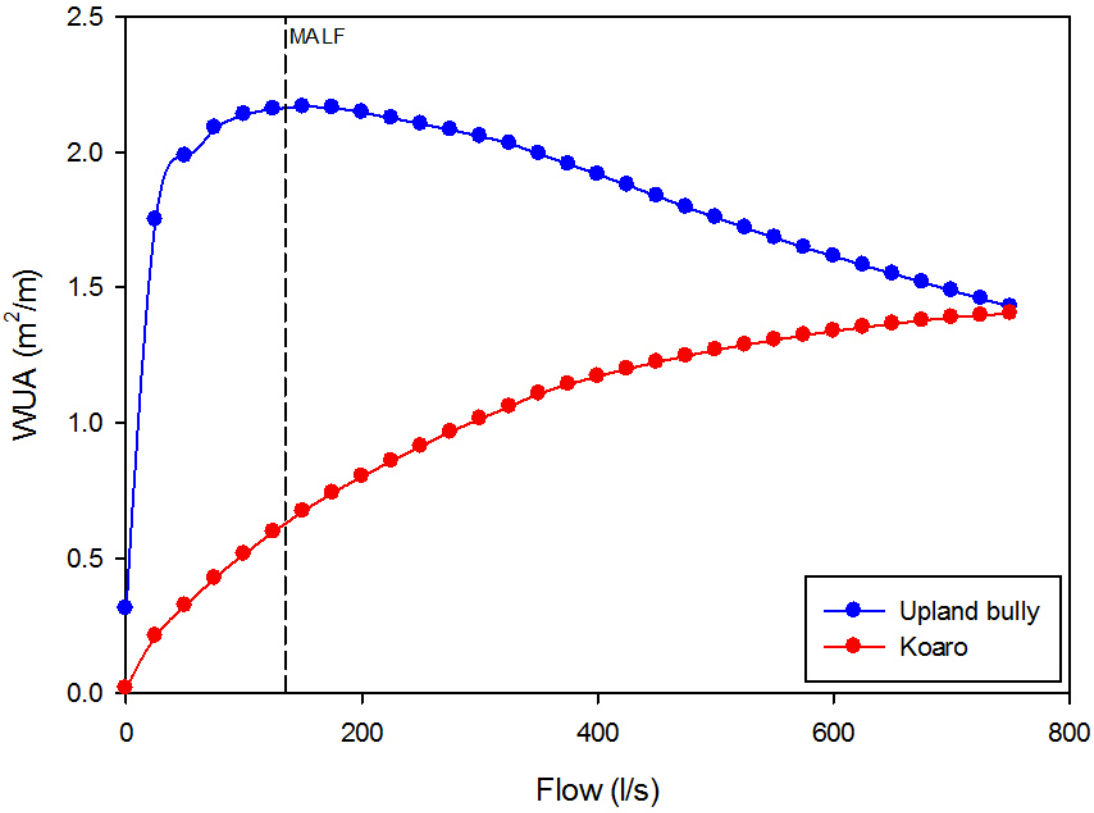


**Figure 5.2** **Variation in in-stream habitat of native fish, in relation to flow, in the survey reach of Twelve Mile Creek. The dotted line represents the 7-d mean annual low flow (MALF).**

**Table 5.3** **Recommended flows requirements for native fish habitat in Twelve Mile Creek, based on the IFIM analysis of Jowett (2005).**

| Species | Optimum flow (l/s) | Flow below which habitat rapidly declines (l/s) | Flow at which the recommended % habitat retention occurs (l/s) |
|---|---|---|---|
| Upland Bully | 160 | 75 | >25 |
| Koaro | >750 | - | 96 |

### 5.3.3 Brown trout habitat

Habitat for adult brown trout increased across the entire modelled flow range, with a flow of 81 l/s predicted to maintain 70% of the habitat at MALF (Figure 5.3, Table 5.4). Flows of 625-675 l/s were predicted to provide optimum habitat for juvenile brown trout and juvenile habitat declined rapidly below 200 l/s (Figure 5.3). A flow of 105 l/s was predicted to maintain 80% of the habitat at MALF (Figure 5.3, Table 5.4). Brown trout spawning habitat was optimum at a flow of 500 l/s (Figure 5.3). A flow of 123 l/s was predicted to maintain 80% of the spawning habitat available at MALF (Figure 5.3, Table 5.4).

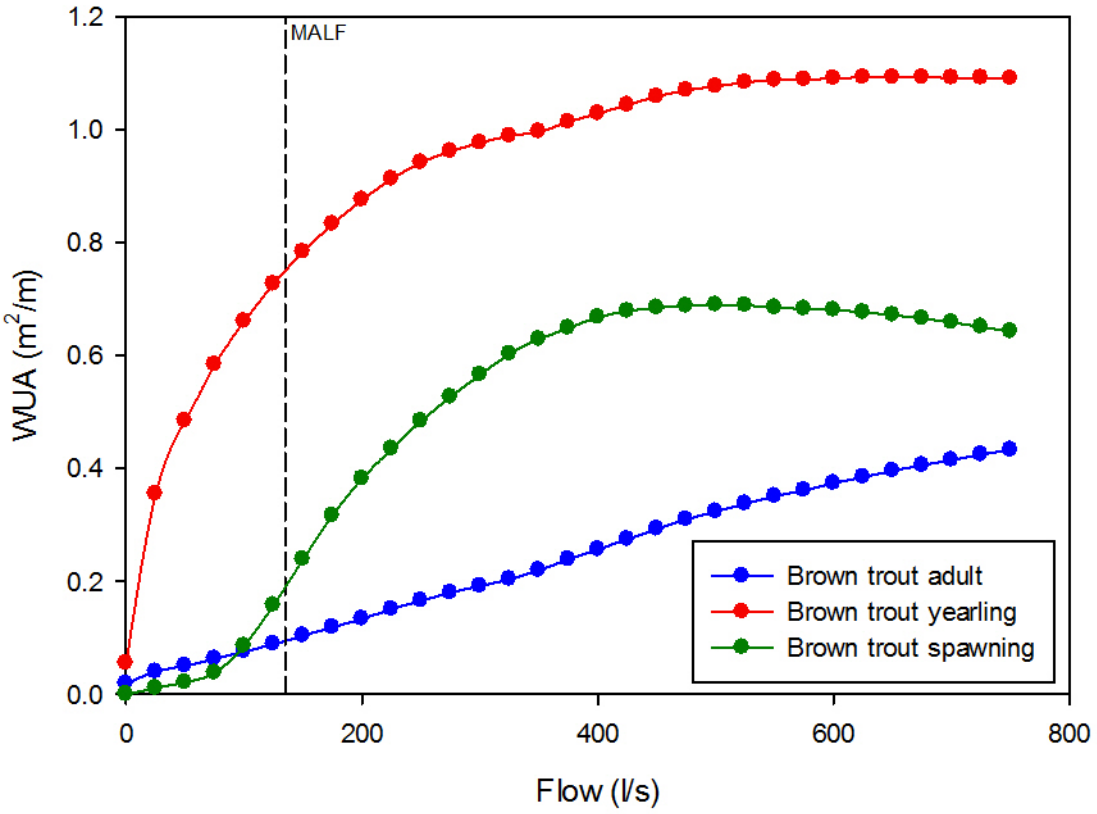


**Figure 5.3** **Variation in instream habitat of various life-stages of brown trout, relative to flow, in Twelve Mile Creek. The dotted line represents the 7-d mean annual low flow (MALF).**

**Table 5.4** **Recommended flow requirements for brown trout habitat in Twelve Mile Creek, based on the IFIM analysis of Jowett (2005).**

| Species | Optimum flow (l/s) | Flow below which habitat rapidly declines (l/s) | Flow at which the recommended % habitat retention occurs (l/s) |
|---|---|---|---|
| Brown trout adult | >750 | - | 81 |
| Brown trout yearling | 625-675 | 200 | 105 |
| Brown trout spawning | 500 | - | 123 |

### 5.3.4 Rainbow trout habitat

Habitat for adult rainbow trout increased across the entire modelled flow range, with a flow of 71 l/s predicted to maintain 70% of the habitat at MALF (Figure 5.3, Table 5.4). Similarly, habitat for juvenile rainbow trout increased across the modelled flow range, with a flow of 93 l/s predicted to maintain 80% of juvenile rainbow trout habitat at MALF (Figure 5.3, Table 5.4). Rainbow trout spawning habitat increased across the modelled flow range, with spawning habitat predicted to decline rapidly below 300 l/s (Figure 5.3, Table 5.4). A flow of 118 l/s was predicted to maintain 80% of the rainbow trout spawning habitat available at MALF (Figure 5.3, Table 5.4).

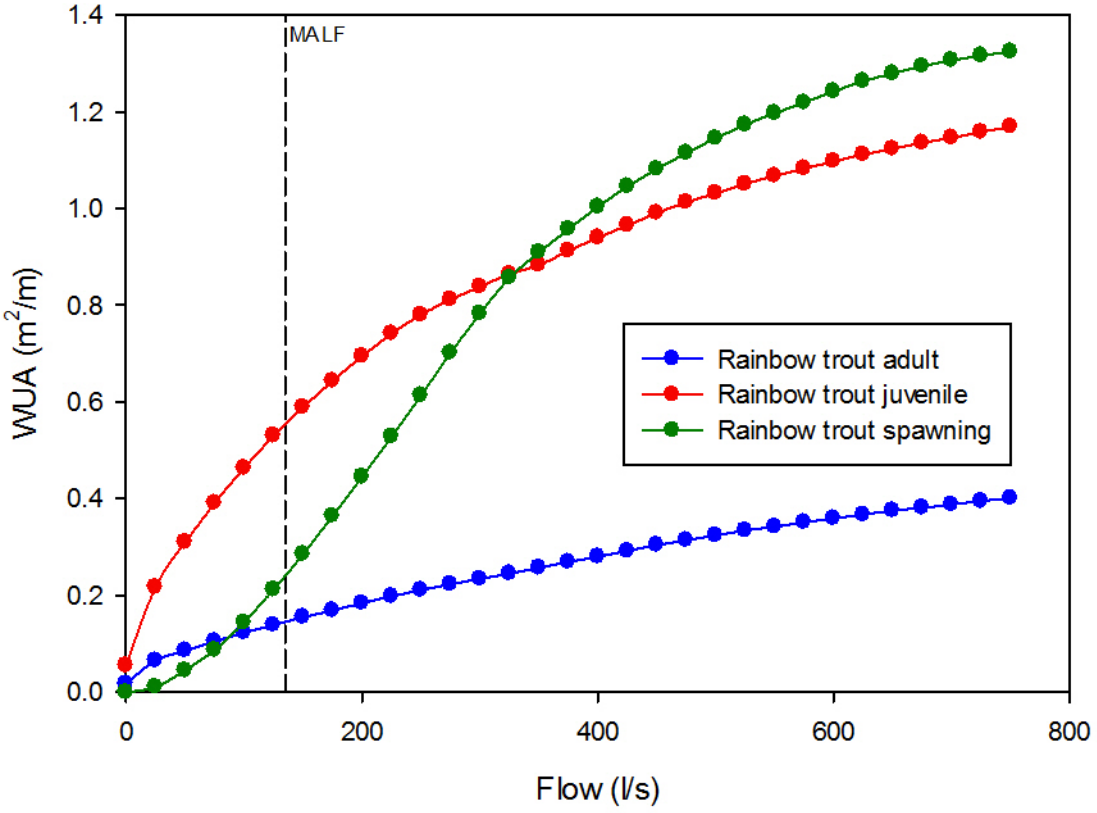


**Figure 5.4** **Variation in instream habitat of various life-stages of rainbow trout, relative to flow, in Twelve Mile Creek. The dotted line represents the 7-d mean annual low flow (MALF).**

**Table 5.5** **Recommended flow requirements for rainbow trout habitat in Twelve Mile Creek, based on the IFIM analysis of Jowett (2005).**

| Species | Optimum flow (l/s) | Flow below which habitat rapidly declines (l/s) | Flow at which the recommended % habitat retention occurs (l/s) |
|---|---|---|---|
| Rainbow trout adult | >750 | - | 71 |
| Rainbow trout yearling | >750 | - | 93 |
| Rainbow trout spawning | >750 | - | 118 |

## 5.4 Summary of instream habitat modelling

Instream habitat modelling for Twelve Mile Creek suggests that a flow of 105 l/s during the months December-April will maintain 80% of the juvenile brown trout habitat available at MALF as well as an appropriate level of protection for koaro, juvenile rainbow trout and adult trout (Table 5.6). Protection of spawning habitat during winter (May-August) for brown trout and during spring (September-November) would require higher flows, with a flow of 120 l/s predicted to provide a high level of protection for the spawning habitat of both species (Table 5.6). The flows required to achieve various levels of habitat retention for each of the fish species considered are summarised in Appendix B.

**Table 5.6** **Recommended flows to maintain fish habitat in Twelve Mile Creek, based on the IFIM analysis of Jowett (2005).**

| Months | 7-d MALF (l/s) | Recommended flow (l/s) | Reason |
|---|---|---|---|
| **December-April** | 135 | 105 | Juvenile trout, koaro, adult trout habitat |
| **May-November** | | 120 | Trout spawning habitat |

# 6 Conclusions: Flow requirements for aquatic ecosystems in the Twelve Mile Creek

Under the Regional Plan: Water Otago, rivers will have minimum flows set to provide for the maintenance of aquatic ecosystems and natural character under low flow conditions. Similarly, residual flows can be imposed on resource consents for the same reasons. The purpose of this report is to provide information that assists in setting minimum or residual flows, including the values present in the Twelve Mile Creek catchment, the existing use of water resources and the flows required to maintain in-stream habitat based on habitat modelling.

Twelve Mile Creek provides spawning habitat for trout and it is likely that it contributes to recruitment to the nationally significant trout fishery in Lake Wakatipu. It provides limited angling for resident adult trout, although the delta where Twelve Mile Creek enters Lake Wakatipu is a popular area for angling. Twelve Mile Creek provides habitat for upland bully and koaro in addition to both rainbow and brown trout. Koaro are classified as “declining” in the most recent assessment of the conservation status of New Zealand freshwater Fish, while upland bully were classified as “not threatened” (Goodman *et al.* 2014).

In-stream habitat modelling predicts that flows to protect juvenile brown trout (105 l/s) during the period December-April will also provide an appropriate level of protection for koaro, juvenile rainbow trout and adult trout. Protection of spawning habitat during winter and spring (May-November) would require higher flows (120 l/s).

Existing allocation in the Twelve Mile Creek catchment is very low (combined maximum instantaneous rate = 6.61 l/s) and is, therefore, unlikely to be having any impact on aquatic life. However, the results of this investigation will be used to inform assessments of minimum or residual flows on future applications to take water from the Twelve Mile Creek catchment.

# 7 Glossary

**Abstraction**
See water abstraction.

**Allocation limit or allocation volume**
The maximum flow or quantity of water in a water body, which is able to be allocated to resource consents for taking.

**Catchment**
The area of land drained by a river or body of water.

**Consumptive use**
Use of water that results in a net loss of water from the water body.

**Instream Flow Incremental Methodology (IFIM)**
An instream habitat model used to assess the relationship between flow and available habitat for fish and invertebrates.

**Instantaneous take**
All takes of water occurring at a particular time.

**Irrigation**
The artificial application of water to the soil, usually for assisting the growing of crops and pasture.

**Main stem**
The principal course of a river (i.e., does not include tributaries).

**Mean Annual Low Flow (MALF)**
The average of the lowest seven-day low flow period for every year of record (see also seven-day low flow).

**Mean flow**
The average flow of a watercourse (i.e., the total volume of water measured divided by the number of sampling intervals).

**Minimum flow**
The flow below which the holder of any resource consent to take water must cease taking water from that river.

**Non-consumptive**
A water use that returns all water to the catchment it was taken from.

**Point of inflection**
The point at which there is a sharp decrease in the available habitat relative to flow in an IFIM habitat curve.

**Primary allocation**
The volume of water established under Policy 6.4.2 of the RPW that is able to be taken, subject to a primary allocation minimum flow.

**Reach**
A specific section of a stream or river.

**Return period**
An estimate of the average interval of time between events (e.g., flood or low-flow event).

**River**
A continually or intermittently flowing body of fresh water that includes a stream and modified watercourse, but does not include any artificial watercourse (such as an irrigation canal, water supply race or canal for the supply of water for electricity power generation and farm drainage canal).

**Seven-day low flow**
The lowest seven-day low flow in any year is determined by calculating the average flow over seven consecutive days for every seven consecutive day period in the year and then choosing the lowest.

**Stock water**
Water used as drinking water for livestock.

**Taking**
The taking of water is the process of extracting the water for any purpose and for any period of time.

**Vegetation**
Plant cover, including trees, shrubs, plants or grasses.

**Water abstraction**
The extraction of water from a water body (including aquifers).

**Water body**
Fresh water or geothermal water in a river, lake, stream, pond, wetland or aquifer, or any part thereof, which is not located within the coastal marine area.

**Water permit**
A permit granted under the Resource Management Act (1991) to take water.

# 8. References

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# Appendix A

## Habitat suitability curves used in instream habitat modelling undertaken by Jowett (2005)

| Species | Habitat suitability curve |
|---|---|
| Upland bully | Jowett & Richardson 1995 |
| Brown trout adult | Hayes & Jowett 1994 |
| Brown trout yearling | Raleigh *et al.* 1986 |
| Brown trout spawning | Shirvell & Dungey 1983 |
| Koaro | Richardson & Jowett 1995 |
| Rainbow trout adult feeding | Thomas & Bovee 1993 |
| Rainbow trout juvenile feeding | Thomas & Bovee 1993 |
| Rainbow trout spawning (Tongariro) | Jowett *et al.* 1996 |

# Appendix B

## Flows predicted to achieve various levels of habitat retention (expressed as a percentage of habitat at MALF) for fish species and life-stages present in Twelve Mile Creek. All flows are in litres/second.

| Species | % habitat retention | | | |
|---|---|---|---|---|
| | 60% | 70% | 80% | 90% |
| Koaro | | 79 | 96 | 115 |
| Upland bully | 17 | 21 | 25 | 46 |
| Brown trout adult | | 82 | 100 | 118 |
| Brown trout yearling | | 60 | 80 | 105 |
| Brown trout spawning | | 116 | 123 | 129 |
| Rainbow trout adult | | 71 | 91 | 112 |
| Rainbow trout yearling | | 74 | 93 | 113 |
| Rainbow trout spawning | | 109 | 118 | 127 |