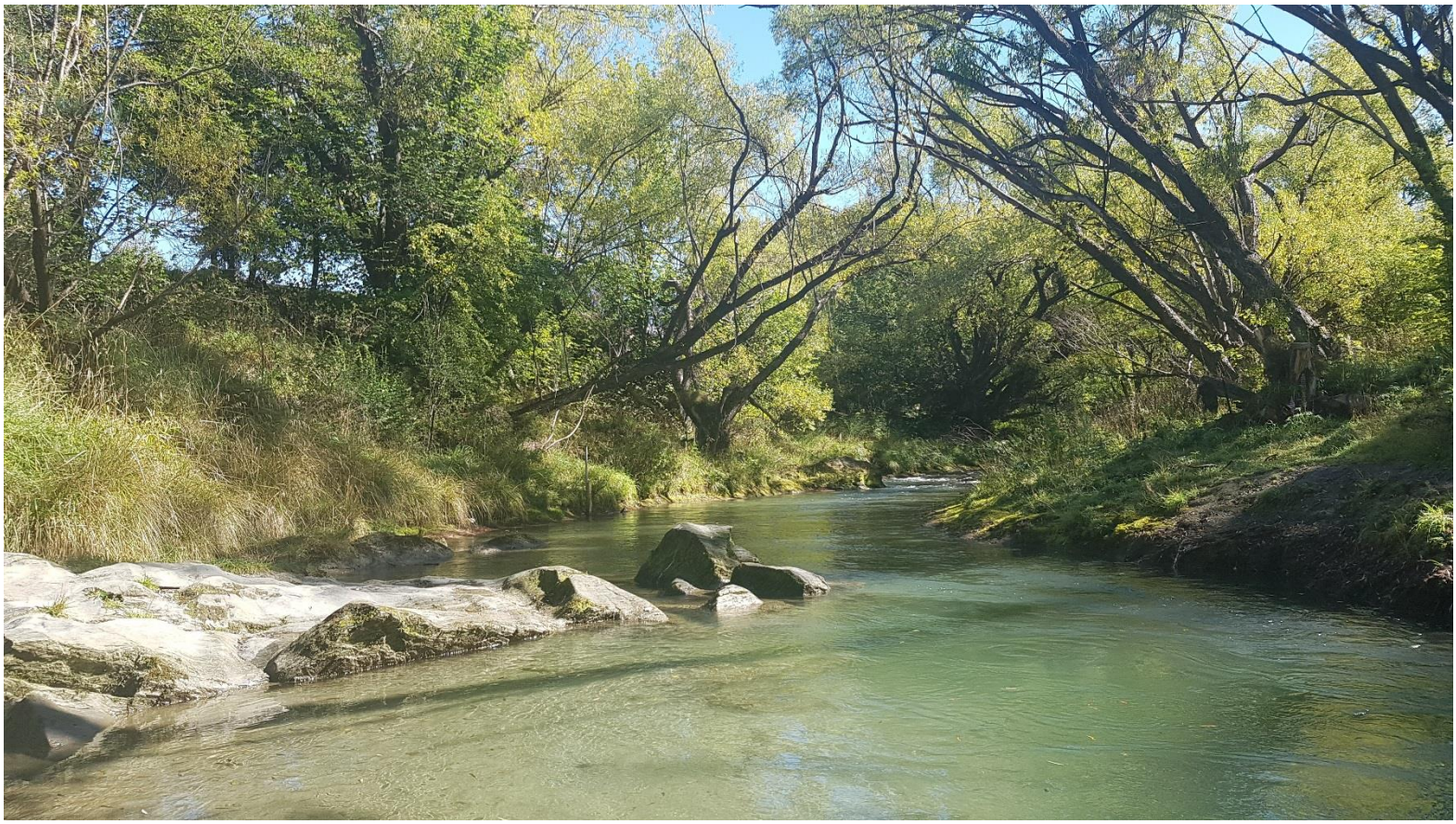
Arrow catchment and Wakatipu Basin Aquifers

Background Report for Options Consultation

December 2017



Otago Regional Council

Executive Summary

Otago Regional Council is undertaking the development of a plan change to the Regional Plan: Water for Otago, as it relates to the management of the amount of water in the Arrow River and the Wakatipu Basin Aquifers. As part of the plan change process, Council have prepared a number of options for the consideration of the community and stakeholders. These options include:

- Setting a primary minimum flow and allocation limit for the Arrow River,
- Setting a corresponding supplementary minimum flow and allocation limit for Arrow River,
- Setting allocation limits to manage the groundwater in the Wakatipu Basin Aquifers.

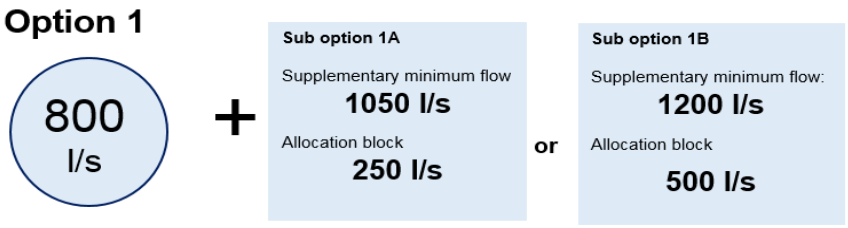
Council commenced the Plan Change earlier in 2017, with the first round of consultation held in June. This round of consultation sought feedback on what was important and valued by the community and stakeholders when it came to water in the Arrow River and the Wakatipu Basin Aquifers. The key values that came out of this consultation included:

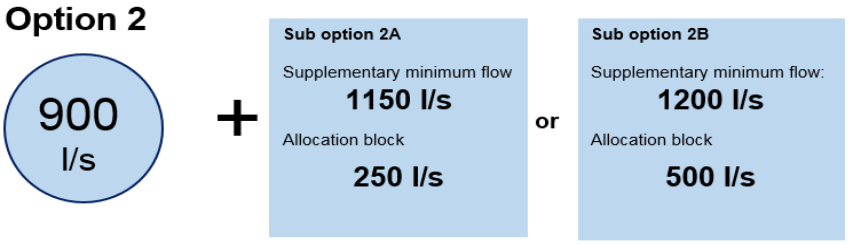
- Recreational use of the Arrow (including fishing, swimming, walking and cycling),
- Physical and visual character of the Arrow and Wakatipu Basin,
- Water supply for community and irrigation use.

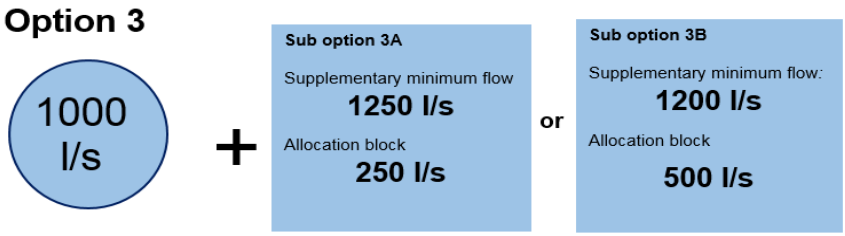
Using the values identified in the first round of consultation, ORC completed science reports for hydrology, instream values and groundwater. We have utilised these reports to develop options to manage the amount of water in the catchment and basin. This background report provides a summary of the key information that has helped us to develop the options.

These options are summarised below:

Primary Minimum Flow and Supplementary Minimum Flow and Allocation Options:







Primary Allocation Limit Options

Option 1

700 l/s

This Primary allocation limit would be set in Schedule 2A of the Water Plan.

Option 2

Status Quo

Existing Policy 6.4.2 - 50% of the 7 day Mean Annual Low Flow.

*Currently this would result in an allocation of **720l/s.***

Alluvial Ribbon Aquifers as Surface Water

The following options apply to the three Alluvial Ribbon Aquifers within the basin. These aquifers have a strong relationship with the associated river.

- Arrow-Bush Ribbon aquifer
- Shotover Alluvial Ribbon aquifer
- Kawarau Alluvial Ribbon aquifer

Option 1

Treated as Surface Water

All takes treated as surface water within associated catchment.

Note: Until minimum flow and allocation is set for the Shotover and the Kawarau Rivers, the status quo will apply.

or

Option 2

Status quo

- Surface water if within 100 m of connected surface water, or
- Groundwater and surface water if >100 m from connected surface water and at least 5l/s stream depletion

Wakatipu Basin Aquifers – Maximum Allocation Limit

The following seven aquifers operate independently of one another and any surface water body, with the exception of Mid Mill Creek Aquifer. They are either confined or unconfined aquifers and as such we can manage the amount of water within them through setting a Maximum Allocation Limit.

	Option 1 • Schedule 4A aquifer. • Sets the Maximum Allocation Limit in the Water Plan.		Option 2 • Status Quo: • Maximum allocation limit is calculated as 50% of mean annual recharge.
Morven Aquifer	0.185 Mm^3/yr	Or	Status quo
Speargrass - Hawthorn Aquifer	0.23 Mm^3/yr	Or	Status quo
Upper Mill Creek Aquifer	0.79 Mm^3/yr	Or	Status quo
Mid-Mill Creek Aquifer	0.51 Mm^3/yr	Or	Status quo
Windemeer / Ladies Mile Aquifer	0.24 Mm^3/yr	Or	Status quo
Frankton Flats Aquifer	0.21 Mm^3/yr	Or	Status quo
Fitzpatrick Aquifer	0.105 Mm^3/yr	Or	Status quo

We are now seeking feedback on the options presented. This will assist us to develop a draft plan change with a preferred option. We are also preparing economic and social assessments of the options to inform the preparation of the draft plan change. These assessments will be made available during the consultation period to also inform the community and stakeholders to identify their preferred option.

Following the consideration of the feedback received during this round of consultation, Council will identify a preferred option and prepare a draft plan change. We will then consult with the community and seek their feedback prior to notifying a plan change. It is at this point that the formal RMA plan change process will begin.

Photo: Wakatipu Basin from the Crown Terrace

1. Introduction

The Otago Regional Council (ORC) is undertaking a plan change to the Regional Plan: Water for Otago (Water Plan). This aims to manage the water quantity of rivers, streams and aquifers in the Arrow catchment and the quantity of water in the Wakatipu Basin Aquifer and the Frankton Flats Aquifer.

Guiding the development of the plan change is the National Policy Statement (NPS) for Freshwater Management 2014 (updated August 2017). Under the NPS, ORC is required to:

- Sustainably manage the taking, use, damming or diversion of freshwater,
- To avoid any further over-allocation of freshwater and phase out existing over-allocation,
- To improve and maximise the efficient allocation and efficient use of water,
- To enable communities to provide for their economic well-being, including productive economic opportunities, in sustainably managing freshwater quantity, within limits,
- Set environmental flows and/or levels for all freshwater management units in its region.

Based on these requirements, ORC is reviewing the Water Plan and where necessary implementing environmental flows and allocation limits to ensure the sustainable management of fresh water in Otago. The Arrow catchment and the Wakatipu Basin's individual aquifers are areas that require these limits to be set.

In June 2017, Council undertook its first consultation process on this plan change. This involved engaging with the community and key stakeholders like Iwi, environmental groups and key industry bodies. This round of consultation investigated the values of the Arrow catchment and the Wakatipu Basin aquifers. The feedback received during this consultation is summarised below and in section 3. It has been used to inform the water management options that have been developed as part of the second stage of consultation.

This second stage of the plan change development sets out a range of management options for the following:

- Arrow River catchment
    - Primary minimum flow
    - Primary allocation limit
    - Supplementary minimum flow and allocation block sizes
- Wakatipu Basin aquifers
    - Identification of aquifers to be treated as surface water (applicable to three aquifers)
    - Maximum allocation limits set for the remaining seven aquifers

This paper provides a summary of the background information for the Arrow catchment and the Wakatipu Basin aquifers. It also sets out the options for the ongoing management of water quantity and the information that has been used to define these options.

2. Background information

The following sections provide background information for the Arrow River and its catchment and the Wakatipu Basin aquifers separately.

2.1. Arrow catchment

2.1.1. Geographical characteristics

The Arrow catchment (236 km^2) is located in the Queenstown Lakes District. The Arrow River flows approximately 50 km in a south-southeast direction from its headwaters, to the south of Arrowtown and the east of Lake Hayes. It runs alongside the terraces of the Wakatipu Basin to its confluence with the Kawarau River. The headwater hills are the Harris Mountains to the west and the Crown Range to mounts Cardrona, Soho and beyond to Mount Motatapu on the east and north.

Soho and Eight Mile creeks and the Rich and Royal burns are significant tributaries of the Arrow River. The tributary, Bush Creek joins the Arrow River at Arrowtown.

Figure 1 sets out the area covered by the Arrow catchment and which is subject to the development of this plan change.

2.1.2. Climate

The climate of the Arrow catchment is continental and characterised by cold winters and warm, dry summers. The catchment has moderate, consistent rainfall throughout the year, with February, March and April receiving lower monthly rainfall totals. The highest annual rainfall totals are within the headwaters of the catchment, with the lower parts of the catchment receiving a median rainfall total in the range of 700-750 mm/year.

2.1.3. Hydrological characteristics

The upper reaches of the Arrow catchment are relatively unmodified with predominately steep tussock-covered mountain slopes. The mid to lower reaches are characterised by a contrast of rocky bluffs and tussock, with the vegetation changing from tall tussock to short tussock and exotic grasses as you move down the catchment.

River flows are the highest from May to November, corresponding with higher rainfall. Melting snow means flows are consistently high in the Arrow during spring. The lowest recorded flows have occurred in the mid-summer/early autumn period (January/April).

Photo: Confluence Arrow River and Bush Creek

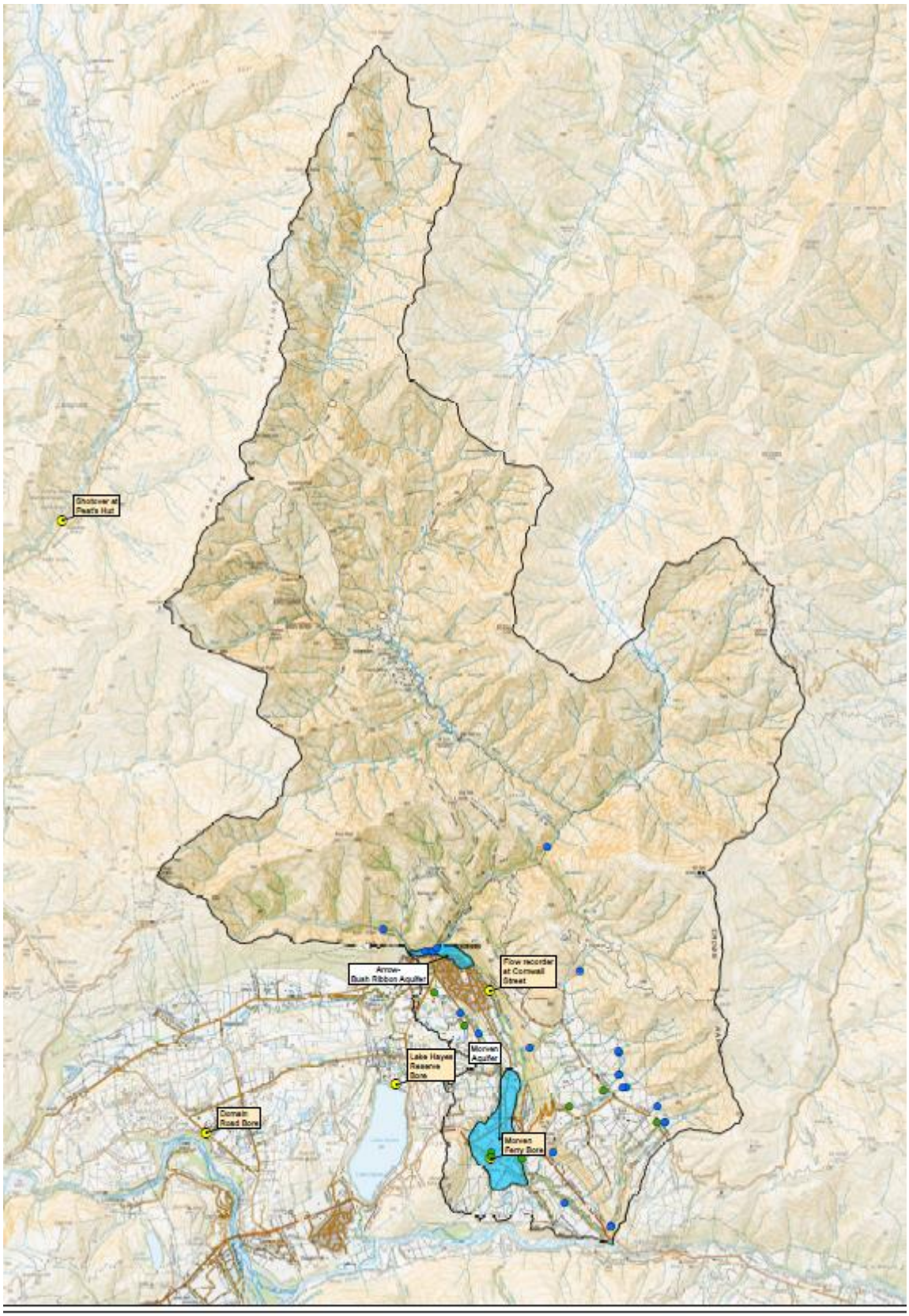


Figure 1: Arrow Catchment

2.1.3.1. Naturalised flows and 7-day low flow

To understand the hydrology of the river and to ascertain how to best manage the instream values, the process of calculating naturalised flows is undertaken, this is important to understand the low flow hydrology. A naturalised flow is a synthetic flow created to simulate the natural flows of a river by removing the effect of water takes or other flow modifications. To do this flow and take data are required.

The former Ministry of Works established a flow site on the Arrow River upstream of Beetham Creek in April 1981. This was removed in January 1994. In December 2010, a flow recorder was established in the Arrow River at Cornwall Street. Using all data available, the flow can be naturalised i.e. – *naturalised flows of the Arrow River, at Cornwall Street = Actual flows at Cornwall Street + all the water takes above the flow site*. It should be noted that although 7 years of flow data is available from Cornwall Street, only four years of time-series water take data is available. Therefore naturalised flows have been calculated for a four-year period only: 2013 -2017.

The detailed calculations and analysis is set out in the ORC Science report – *Update of scientific information on the Arrow Catchment 2017 (1)*. This analysis identifies the estimated average naturalised 7-day mean low flow (7dMALF) between 2013 – 2017 to be in the range of 1.431 – 1.441 m^3/s.

2.1.3.2. Water temperature

Water temperature is a fundamental factor affecting all aspects of stream systems. It can affect fish populations both directly (influencing survival, growth, spawning etc) and indirectly (effects on food supply, periphyton growth and other physiochemical conditions). In the Arrow River, brown trout and rainbow trout are most likely to be sensitive to high water temperatures. Limited water temperature data is available for the Arrow River, with only three months available (December 2010 – April 2011). However, the temperature recorded during this period is well within the thermal tolerances of brown and rainbow trout.

2.1.4. Environmental Values

The Arrow River supports a large variety of species and habitat for the diverse life cycle requirements of a range of species. The gravel and sand bed composition is of importance for resident biota, the presence of trout, significant fish spawning areas and areas for the development of juvenile fish.

The species of stalked diatom, commonly known as didymo is known to have been present in the catchment. Whilst the presence of native diatoms is generally considered a desirable component of the periphyton community, didymo is non-native and is an invasive diatom which affects recreation and ecosystem values.

Specifically, the following aquatic ecosystem values have been identified for the Arrow River (1):

- Native fish – there is a single record of the presence of an indigenous fish species documented within the Arrow catchment. This fish, Koaro, was recorded in the main-stem of the Arrow River near the confluence with Soho Creek. It is not known if the Koaro persists in other parts of the catchment, however if it does its abundance would be very low. It is listed as an ‘at risk, declining’ species in the most recent threat classification (2).

- Trout – The Arrow River is considered to support a locally significant sports-fish fishery. Fish survey records indicate that no trout have been recorded in the Arrow River above the confluence with Soho Creek. Below the confluence a healthy presence of brown trout has been recorded, particularly within Soho Creek. Rainbow trout appears to have a restricted distribution located within the lower reaches of the Arrow River, downstream of the gorge.
- Invertebrates – a diverse range of aquatic invertebrates are present in the catchment.

2.1.5. Cultural values

A cultural value report for the Arrow River and the Wakatipu Basin Aquifers has been prepared by Aukaha (formerly known as KTKO) on behalf of Te Rūnanga o Moeraki, Kāti Huirapa Rūnaka ki Puketeraki, Te Rūnanga o Ōtakou and Hokonui Rūnanga (Kāi Tahu Otago) and Te Rūnanga o Waihōpai, Te Rūnanga o Awarua and Te Rūnanga o Ōraka-Aparima (Kāi Tahu Ki Murihiku) (3). This report identifies the following key values for the Arrow River catchment:

- Ara tawhito (trails) ran through the catchment, bringing whānau into the southern lakes and rivers,
- Clear water and protection of the remaining indigenous fish,
- Recreation use, including values of Mahinga Kai.

2.1.6. Economic values

There are a number of commercial activities within the Arrow catchment including agriculture, recreation, tourism, accommodation and hospitality which rely on the taking of water, and the physical, historical and aesthetic qualities of the river. Extensive pasture grazing occupies the hilly upper catchment, while the lower, flatter land is utilised for more intensive grazing, residential, commercial tourism and lifestyle activities.

The major irrigation scheme in the Arrow catchment is operated by the Arrow Irrigation Company. Their scheme is reliant on gravity-fed pipelines and manually controlled open races for transporting water, which is supplied to a customer base within the Arrow catchment and beyond to the Wakatipu Basin.

2.1.7. Water takes

22 consumptive surface water take consents occur within the Arrow catchment, including surface water takes from community water supply bores within the Arrow-Bush Ribbon Aquifer. This includes 14 deemed permits, formerly called mining privileges. These mining privileges were issued under mining legislation, and provided for the taking, damming and discharging of water and use of water races. However, as gold mining declined, this water was increasingly used for irrigation. The amount of water consented on these permits is often very large and is not taken in full by the permit holder. When the Resource Management Act (RMA) was introduced in 1991, it set an expiry date of 1 October 2021 for all deemed permits. A resource consent will then be required in place of the deemed permit, with the water allocation likely to reflect the quantity of water that is currently being used.

On paper the total consented amount of water for the 22 consents is 2,030 l/s. This authorised total exceeds 50 per cent of the naturalised 7-day mean annual low flow (1,431 – 1,441 l/s). 50 per cent of MALF would be between 715.5 – 720.5 l/s for the catchment. Therefore, on paper the catchment is

approximately 2.8 times over-allocated. However, the actual takes are significantly less than that authorised.

Across the four-year data set (13/14 – 16/17 irrigation seasons) available for measuring water takes, on average the largest amount that has been taken is 596 l/s. Hence a continuous flow has been present in the mainstem. This flow may not persist if authorised takes were exercised more closely to their full allocation.

It should be noted that the groundwater takes that are within the Morven Aquifer, and within the Arrow catchment, are dealt with under section 2.2.3 which sets out the groundwater takes in the Wakatipu Basin aquifers.

2.2. Wakatipu Basin aquifers

2.2.1. Geographical characteristics

The 2014 ORC report *'Investigation into the Wakatipu Basin Aquifers'* (4) found that the Wakatipu Basin aquifers were scattered areas of glacial gravel deposits, separated by schist ridges and major bedrock hills, such as Slope Hill and Morven Hill. The following aquifers have been identified within the Wakatipu Basin and were reviewed as part of updated investigations into calculating their Mean Annual Recharge in 2017 (5). Please note that the Fitzpatrick Aquifer was not identified within the 2014 report but has been identified in more recent work undertaken in 2017 by ORC (6,7):

- *Upper Mill Creek Aquifer* – elongated valley deposit, following upper Mill Creek until the creek passes onto low permeability schist rock and the Millbrook waterfall.
- *Mid Mill Creek Aquifer* – begins just north of Waterfall Park Road, at the base of the Millbrook waterfall, and ends at the shore of Lake Hayes. In this location Mill Creek is thought to be perched above the water table, allowing for water loss infiltration through the creek bed to the aquifer.
- *Windemeer Aquifer (Ladies Mile)* – located on the true right bank of the Shotover River the aquifer is split to south-east and south-west by a schist rock ridge overlooking the Kawarau River. There is a low groundwater gradient across the aquifer and the depth of the water table can be very deep in parts, up to 40 m. It is assumed that no recharge occurs from Lake Hayes.
- *Speargrass-Hawthorn Aquifer* – this aquifer is adjacent to the Mid Mill Creek Aquifer at Mooneys Swamp, but grades south-west towards the Shotover River. It has a gentle groundwater gradient, suggesting permeability.
- *Morven Aquifer* – this aquifer consists of outwash terraces (glacial sediments deposited at the former terminus of a glacier) and alluvium associated with the Arrow River, although the river makes very little (if any) direct contact with the aquifer. The aquifer thickness is highly variable, from 3 m in some bores, to 25 m in a single bore in the south east. A hydraulic gradient to the south-east is present.
- *Arrow-Bush Ribbon Aquifer* – is a small alluvial aquifer at the confluence of Bush Creek and the Arrow River. The Arrow River, and to a lesser extent Bush Creek, recharge the aquifer. Drilling in the aquifer has encountered sandy gravels, underlain by schist bedrock and a presence of a silty horizon. The aquifer thickness is quite variable, with the deeper parts of the aquifer present on the western area.

- *Frankton Flats Aquifer* – The aquifer terminates at the Lake Wakatipu boundary, which is formed by low permeability lake sediments. It is a highly transmissive (allowing water to pass through it) outwash aquifer with connection to Lake Wakatipu, Kawarau River and Shotover River. It is thought that there is a dynamic equilibrium between these water bodies and the aquifer.
- *Fitzpatrick Aquifer* – comprised of late Pleistocene sediments. Due to topography and a thin layer of Pleistocene sediments, which don't allow water to pass, it is determined that the aquifer is separate to the Speargrass-Hawthorn Aquifer which shares its western boundary.
- *Shotover Alluvial Ribbon Aquifer* – highly connected with the Shotover River, hence the Shotover River would recharge the aquifer.
- *Kawarau Alluvial Ribbon Aquifer* – highly connected with the Kawarau River, hence the Kawarau River would recharge the aquifer.

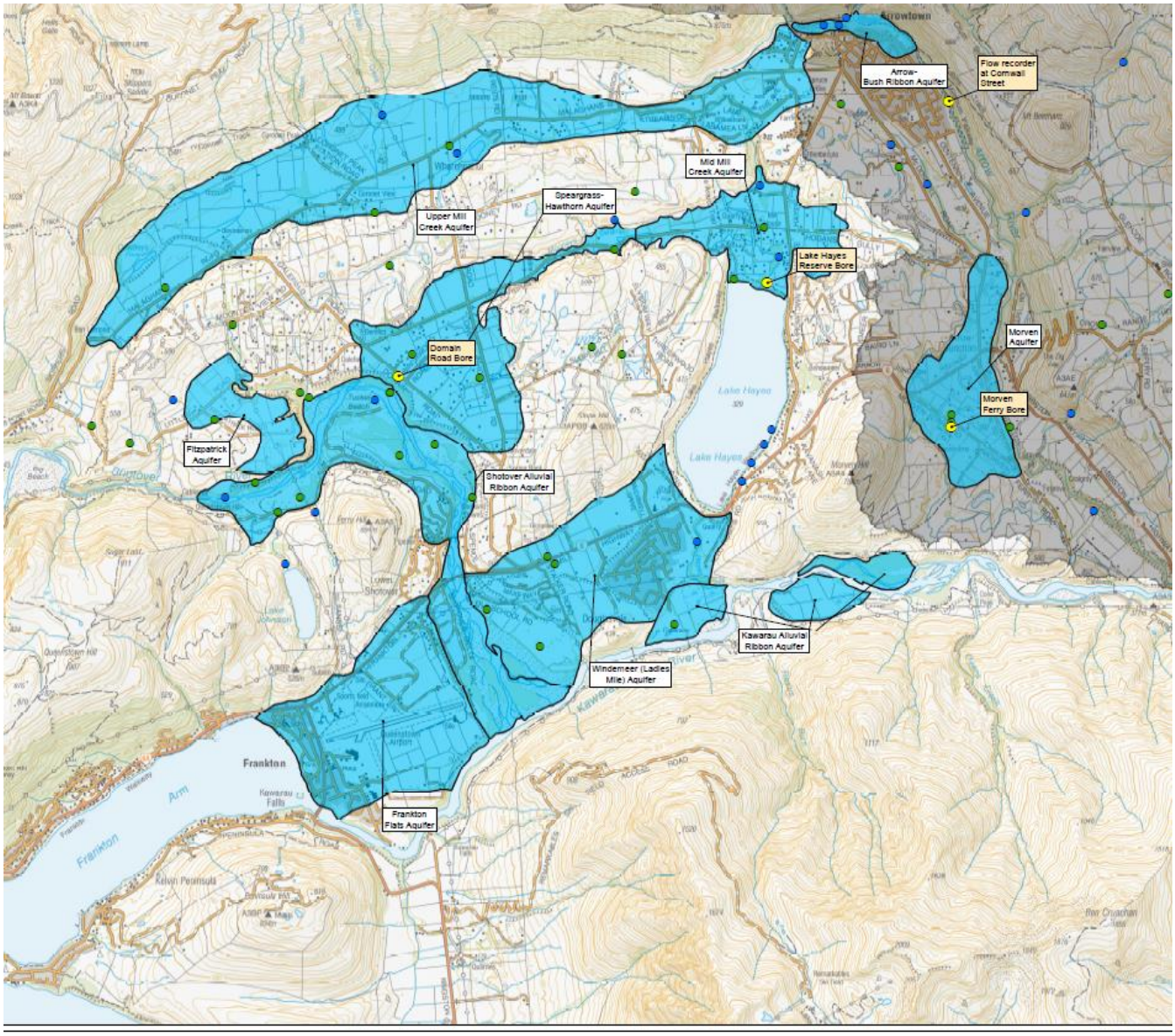
The above aquifers are shown on Figure 2.

The aquifers are naturally replenished by rainfall, rivers, creeks, feed springs and out-flowing seepage into the basin. Rainfall recharge modelling undertaking in 2014 indicated that almost 25 per cent of rainfall contributes to groundwater recharge in the Wakatipu Basin. However, it is acknowledged that this would be different across the Basin dependant on the land slope and underlying geology. For example, rain falling on the slopes of Morven Hill, and other schist ridges in the Basin would not be expected to have a significant recharge effect.

2.2.2. Environmental values

Given groundwater is not visible, instances of over-allocation and water quality being affected by contaminants often catch communities by surprise. Maintaining appropriate groundwater levels is important in minimising the risk of aquifer recharge with contaminated water. As such, the need to manage the allocation of groundwater as identified through this plan change.

Besides the alluvial ribbon aquifers, the remaining aquifers are unconfined or semi-confined and therefore at risk of recharge from contaminants. The risk to water quality of groundwater in the Wakatipu Basin aquifers comes from the industrial areas adjacent to Arrowtown and on Frankton Flats, the Tuckers Beach former landfill and the change in land use from rural to residential and its associated stormwater run-off. However, at present the groundwater within the Wakatipu Basin aquifers is generally of a very good quality.



Wakatipu Basin aquifers

Figure 2 – Wakatipu Basin Aquifers

2.2.3. Cultural Values

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- Concern for water quality of the aquifers as it relates to the amount of water in the aquifers, particularly in relation to changing land use,
- A number of wetlands are existing in the basin and have biodiversity values.

2.2.4. Water takes

The Wakatipu Basin Aquifer is now known to be comprised of several distinct aquifers, plus alluvial ribbon aquifers associated with the principal rivers of the Shotover and Kawarau. The aquifers are mainly used for providing domestic water to public, communal and individual water supplies, with very little high volume taking for irrigation or industry.

In those distinct non-ribbon aquifers, 14 consents are authorised to take 1.09 Mm^3/year in total. This information is set out in Table 1 below. Total known actual annual groundwater takes, from all seven aquifers, under these consents is in the order of 0.325 Mm^3/year. It should be noted that many water takes are minor takes which are not monitored and are therefore not reflected in this calculation.

Aquifer	Mean annual recharge (Rainfall LSR)	Mean annual recharge (surface water)	50% of total mean annual recharge (Mm^3/y)	Total consented takes (in Mm^3/y)
Frankton Flats Aquifer	0.42	-	0.21	0
Windemeer Aquifer (Ladies Mile Aquifer)	0.48	-	0.24	0.138
Mid Mill Creek Aquifer	0.39	0.63	0.51	0.016
Morven Aquifer	0.37	-	0.185	0.010
Speargrass-Hawthorn Aquifer	0.46	-	0.23	0.041
Upper Mill Creek Aquifer	1.57	-	0.785	0.022
Fitzpatrick Aquifer	0.21		.105	0.058

Table 1 – Summary of consented takes Wakatipu Basin aquifers

As demonstrated above, none of the aquifers are currently over-allocated in terms of the existing policies in the Water Plan (6.4.10A2b) of calculating 50 per cent of MAR.

As the Shotover Alluvial Ribbon Aquifer and the Kawarau Alluvial Ribbon Aquifer are considered to have connection with the Shotover or Kawarau Rivers, they are proposed to be treated as surface water, as such no Maximum Allocation Limit will be set for the aquifers. They will be subject to the allocation limits and the minimum flows that may be applied to the Shotover and Kawarau Rivers in future plan change processes. However, set out below is the total number of consents and consented take amount for each aquifer. Please note that the Arrow-Bush Ribbon Aquifer is part of the Arrow catchment's surface water.

Aquifer	Total consented takes (in Mm^3/y)	No. of consented takes
Shotover Alluvial Ribbon Aquifer	0.235	12
Kawarau Alluvial Ribbon Aquifer	0.252	1

Table 2: Summary of water takes in Alluvial Ribbon Aquifers for Shotover River and Kawarau River

3. Feedback on values consultation

In June 2017 ORC held three consultation sessions with the community. Two in Arrowtown (26 June) and one in Frankton (27 June). This was the first stage of the consultation for the development of the plan change and it consisted of a brief presentation followed by informal drop-in sessions. The purpose of the consultation was to identify what was important to the community with regard to the Arrow catchment and the Wakatipu Basin aquifers.

At these sessions, the public could interact with a number of displays and resources designed to facilitate thoughtful discussion and to provide background information to help people identify what it is they value about water in the catchment and Basin. The presentation provided an overview of the plan change and its process.

A detailed summary of feedback received during the consultation sessions and over the subsequent feedback period can be found on the Arrow and Wakatipu Basin Plan Change page on Council's website (https://www.orc.govt.nz/plans-policies-reports/regional-plans/water/arrow-catchment-and-wakatipu-basin-aquifers) . Set out below is a summary of the key themes from the consultation period:

- Recreation use and values featured strongly when ORC asked the community how they used or interacted with water associated with the Arrow catchment. Recreation included a wide range of activities including fishing, swimming, walking, cycling, and enjoying the natural environment. Household use and irrigation (i.e. small orchards, gardens, golf courses) were also identified as key users.
- The physical and visual character of the Arrow River and its value to the community was identified as being highly important to those who participated in the "dotmocracy" activity at the consultation sessions. 96 per cent of participants either agreed or strongly agreed with the statement. This was met with a similar level of importance placed on water being available for community drinking.
- When asked why the Arrow River and Wakatipu Basin aquifers are important to the community a range of responses were received including – water supply, habitat for freshwater species, recreation values and tourism, natural landscape and aesthetic values and the health benefits to the broader community through providing a connection to a high quality natural environment.
- People were concerned with the amount of water in the Arrow River identifying that low flows would have an impact on many recreational uses, specifically a conflict between the irrigation season and fishing or tourism was identified.
- The elements which the community would like to see ORC take into consideration when setting a minimum flow and allocation limits included the following – fair allocation, river health and aquifer replenishment. Giving consideration to water quality benefits and to start with an environmental bottom line.
- When asked what features of the community are important, iconic and pristine landscapes were identified, along with a desire to see sustainable development and avoidance of over-development. Community resilience was also identified, with specific importance placed on the link to the natural landscape.

- Sustainable economic growth that is diverse and provides for community reliance through permanent employment was seen as important. Economic activities listed included, farming, horticulture, viticulture, tourism and retail.
- Feedback was also received expressing concern regarding the over-development of the basin and the impact this is having on the natural landscape.

4. Options

The options identified for managing the amount of water in the Arrow catchment and the Wakatipu Basin aquifers are provided below. An assessment of these values against those identified through the first stage of consultation is provided in section 5.

4.1. Arrow River catchment

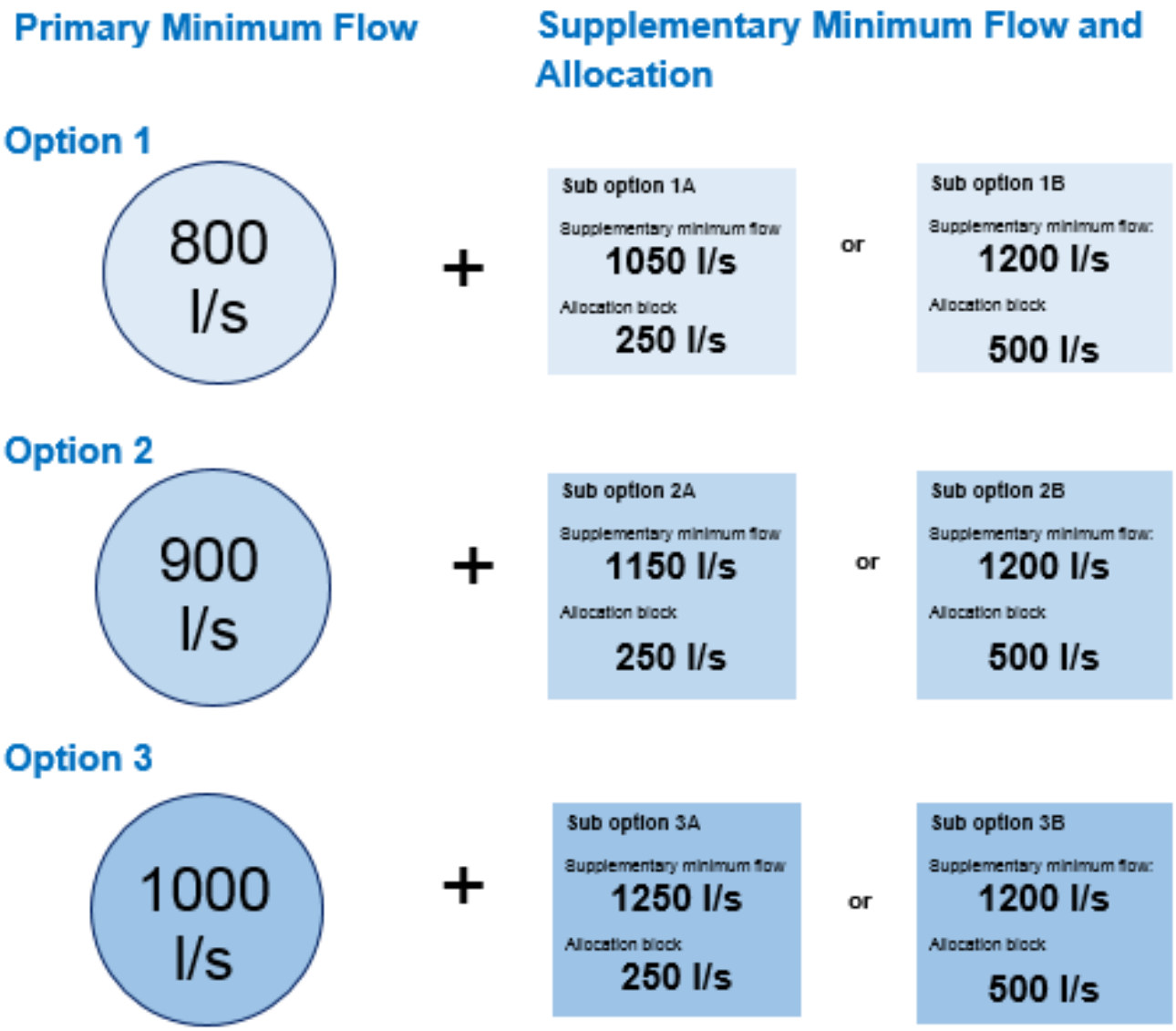
4.1.1. Minimum flow and supplementary minimum flow and allocations

To provide context for the minimum flow options set out below, the MALF for the Arrow River is between 1.431 – 1.441 m^3/s (1431 – 1441 l/s). Mean daily actual flow at Cornwall Street is 2.992 (m^3/s), calculated from flows recorded during the irrigation season (October – April). Therefore, the Arrow River is a flowing river that does not dry naturally.

The flow options below have been developed taking into consideration the aquatic ecosystem management objectives for the Arrow catchment and the values identified through stage one consultation which focussed on maintaining a flow which would support recreational use and the existing natural character.

Many of the aquatic ecosystem values such as fish habitat, natural character, limiting the risk of proliferation of long filamentous algae and protecting macroinvertebrate communities have optimal flows. These flows were used to determine the starting point for developing flow options. The starting point has been identified as 800 l/s, below which nuisance algae becomes difficult to manage and hence many of the values identified could be affected. Economic and social assessments of these options are currently being developed and will be taken in to consideration when the preferred option analysis is undertaken.

Photo: Arrow River Cornwall Street Site



Methodology for supplementary minimum flow and allocation:

1A, 2A and 3A: This method is different to that which is the default approach in the Water Plan and has been developed in response to the specific characteristics of the Arrow catchment.

Supplementary minimum flow = minimum flow + allocation block size of 250l/s

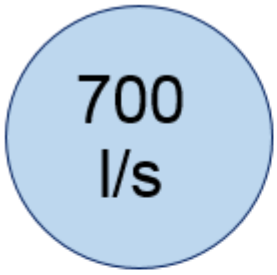
1B, 2B and 3B: It applies existing Policy 6.4.9 from the Water Plan and assumes full primary allocation and actual takes of 700l/s.

Supplementary minimum flow = assessed actual take + allocation block size of 500l/s

4.1.2. Primary Allocation

Set out below are the two options for the Primary Allocation Limit which have been developed with consideration given to the 7-day MALF and the current actual water takes.

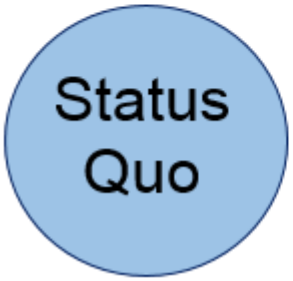
Option 1



This Primary allocation limit would be listed in Schedule 2A of the Water Plan.

Or

Option 2



Existing Policy 6.4.2 - 50% of the 7 day Mean Annual Low Flow.

*Currently this would result in an allocation of **720l/s.***

4.2. Wakatipu Basin aquifers

4.2.1. Groundwater treated as surface water

Due to the connectivity of the following aquifers with surface water, any future water takes are likely to be treated as surface water. Two options have been identified, as set out below.

Option 1

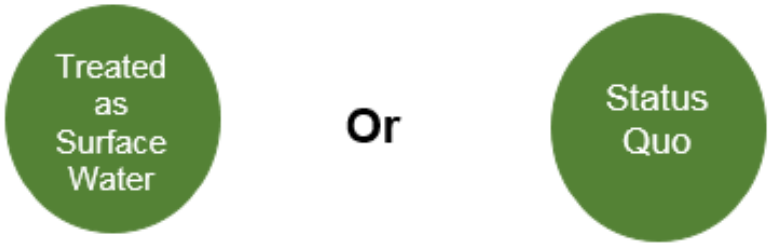
- Listed in Schedule 2C of the Water Plan and mapped.
- All takes treated as surface water within the associated catchment.

Note: Until minimum flow and allocation is set for the Shotover and the Kawarau Rivers, the status quo will apply.

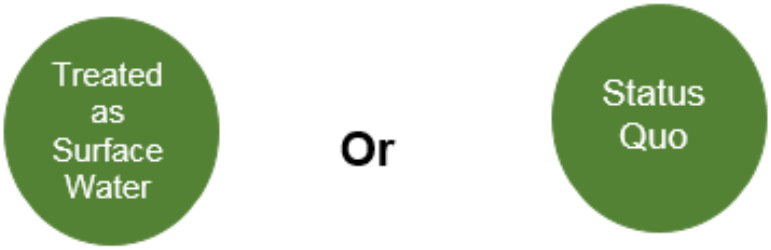
Option 2

- Status Quo.
- Not specifically listed in the Water Plan as a mapped Schedule 2C aquifer.
- Surface water, if within 100 m of connected surface water, or
- Groundwater and surface water if >100 m from connected surface water and at least 5 l/s stream depletion.

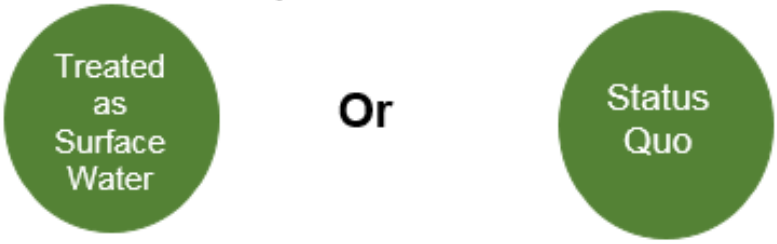
Arrow-Bush Ribbon Aquifer



Shotover Alluvial Ribbon Aquifer



Kawarau Alluvial Ribbon Aquifer



4.2.2. Maximum Allocation Limits

The following aquifers are to be treated as groundwater, and two options have been identified to manage the amount of water within each aquifer.

	Option 1		Option 2
	• Schedule 4A aquifer. • Sets the Maximum Allocation Limit in the Water Plan.		• Status Quo: • Maximum allocation limit is calculated as 50% of mean annual recharge.
Morven Aquifer	0.185 Mm^3/yr	Or	Status quo
Speargrass - Hawthorn Aquifer	0.23 Mm^3/yr	Or	Status quo
Upper Mill Creek Aquifer	0.79 Mm^3/yr	Or	Status quo
Mid-Mill Creek Aquifer	0.51 Mm^3/yr	Or	Status quo
Windemeer / Ladies Mile Aquifer	0.24 Mm^3/yr	Or	Status quo
Frankton Flats Aquifer	0.21 Mm^3/yr	Or	Status quo
Fitzpatrick Aquifer	0.105 Mm^3/yr	Or	Status quo

5. Summary assessment of options

5.1. Arrow Catchment

5.1.1. Minimum flow options

Set out below is an assessment of the flow options against the values and objectives identified through values consultation and research undertaken including scientific factors. The likely level of impact on values at each flow has been assessed in the table below.

	Unacceptable outcome
	Marginal outcome
	Adequate outcome
	Desired outcome or better

Values	Objective	Minimum Flow Options			Comments
		800 l/s	900 l/s	1000 l/s	
Natural character	Maintain flow connectivity				The continuous flow of the river was identified as being very important to the community and region. A continuous flow supports recreation use and tourism and all options will achieve an adequate or desired outcome.
Water quality	Maintain/enhance water quality				Water quality is very good in the Arrow and expected to remain the same across the options.
	Water temperature				Indication is that water temperatures within the river will be suitable for all fish species, and effects between the flow options will be small.
Life-supporting capacity - Periphyton	Avoid nuisance growth of Periphyton – *Phormidium*				Habitat quality was predicted to be similar to that at the naturalised MALF, and hence differences in effects between the flow options will be small.
	Avoid nuisance growths of Periphyton – Didymo				Habitat quality was predicted to be similar to that at the naturalised MALF, and hence effects differences between the flow options will be small. Didymo has been present.
	Avoid nuisance growths of Periphyton – long filamentous algae				A flow of 800 l/s is predicted to increase significantly the risk of proliferation of long filamentous algae (136% of habitat retention), compared with 1000 l/s (119% of habitat retention).
	Avoid nuisance growths of Periphyton – short filamentous algae				A flow of 800 l/s is predicted to increase significantly the risk of proliferation of short filamentous algae (150% of habitat retention), as a result of increased rate of accrual due to more favourable habitat conditions. Habitat retention at 1000 l/s is expected to be 133%.

Values	Objective	Minimum Flow Options			Comments
		800 l/s	900 l/s	1000 l/s	
	Avoid nuisance growths of Periphyton – diatoms				Habitat quality for diatoms is predicted to decline with decreasing flows. However, this assessment represents desirable, native diatoms, so higher levels of habitat retention are environmentally better with higher flows (59%, 67% and 74% respectively across the flow options).
Life-supporting capacity – macroinvertebrates	Maintain biodiversity				Macroinvertebrate communities dominated by mayflies, stoneflies and caddis flies are considered to be more desirable than those dominated by snails and midges. The former is better food for fish such as trout. All flows support this.
	Maintain food-producing habitat				Across the three flows a similar amount of food-producing habitat measured by habitat for the common mayfly *Deleatidium* is predicted to occur.
Life supporting capacity – native fish	Maintain Koaro habitat				Only one species of native fish present in catchment (koaro), very limited distribution and uncommon. Generally, the higher the flow the greater the available habitat for koaro.
Habitat for sports fish (trout)	Brown trout (adult)				Known habitat for trout in Soho Creek and below the confluence, all the flows will support habitat retention.
	Juvenile Trout				Known spawning and rearing habitat for trout and all the flows will support habitat retention.
	Adult Trout (Wilding)				Reflects the slightly different habitat requirements between Brown and Rainbow Trout. Rainbow trout appear to be restricted in distribution to the lower reaches of the Arrow River.
Water surety (irrigation season) – based on ORC data	Average seasonal surety for the years 2013-2017				Initial work shows the average seasonal surety was above 95% for all flows.
	Average seasonal surety for a dry season (2015/16)				Seasonal surety would have dipped below 85%, reflecting 84.4% under option 1000 l/s.
	Average number of days below flow a wet season (2016/17)				Initial work indicates 100% surety is achieved across every flow option during a wet year.
Recreation use	Water based activities (i.e. swimming, gold panning, fishing)				The greater river flows will result in a reduction of the habitat supporting periphyton, and an improvement in food-producing macroinvertebrates which supports fishing. Hence, the higher minimum flows better support recreation activities such as paddling, swimming and fishing.
	Land based activities (walking, tramping, picnics, social gathering)				The value of river flow to land based activities is reflected in how the flow contributes to the natural character. All flows will support natural character and the recreation activities associated with it, although the higher flow of 1000l/s is moving closer to naturalised MALF and hence better reflects the physical character identified in the values.

Values	Objective	Minimum Flow Options			Comments
		800 l/s	900 l/s	1000 l/s	
Tourism	The iconic nature of The Arrow River as it flows behind Arrowtown.				Tourism relates to the recreation activities which the natural character and flow of the river support, with activities including fishing, walking, tramping etc. Tourism also relates to being able to take water from the river to support uses such as the golf resorts. Hence there is potentially an opposing requirement for different areas of tourism, particularly at the higher flow. All flow options would achieve a desired outcome, but with potential increased risk of lower water availability for irrigation during a dry year at a minimum flow of 1000 l/s.

5.1.2. Primary Allocation Limit options

Two options have been developed to set a primary allocation limit for the Arrow River. There is little difference in the amount of water allocated between the two options. The difference between the two options is considered to be mainly one of process.

Whilst the catchment is over-allocated on paper, the actual take data indicates much less is being taken. It is likely, as deemed permits expire or are replaced with resource consents, that the paper primary allocation will drop to more closely align with actual take.

	Pro	Cons
Option 1: Set a Primary Allocation Limit of 700 l/s, and insert this into Schedule 2A.	• Is in line with the current actual take. • Provides clarity by including in the Plan. • Is consistent with the accepted practice of setting allocation limits at 50% of MAR. • Will provide surety for those with existing primary allocation, including those replacing deemed permits as it closely reflects existing takes.	• Provides slightly less allocation than applying the status quo default policy.
Option 2: Status quo – apply default policy of 6.4.2 (50% 7dMALF would be 720 l/s)	• Is in line with the current actual take.	• Allocation limit will rely on the calculation being undertaken as per the status quo policy.

5.1.3. Supplementary minimum flow and allocation blocks

Set out in Section 4.1 are the corresponding supplementary minimum flows and allocation blocks for each of the primary minimum flow options and the reasons for applying the methodology. Essentially the two approaches are to 1) set a supplementary minimum flow and allocation block in the Water Plan or 2) allow for the existing policies and methodology to apply on a case-by-case basis. Different methodologies are proposed for each option, hence selecting between the two options is really a choice between the two methodologies. Set out below is an overview of the pros and cons of each methodology.

	Pros	**Cons**
Option 1: Inserting the Supplementary Minimum Flow and Allocation Block into Schedule 2B using the following methodology: *Supplementary minimum flow = minimum flow + allocation block size of 250 l/s*	• Provides certainty for supplementary allocation. • Using primary minimum flow as the basis for calculating the supplementary minimum flow will ensure ecological values for the river are not adversely affected by supplementary takes. • Enables a finer grain 1:1 sharing regime between water takes and river above the primary minimum flow. • Enables a gradual approach to supplementary allocation which will provide better surety for those with supplementary allocation, particularly in the first block. • Associated supplementary minimum flows will be lower than alternative approach.	• Perception that the smaller allocation block size (than that provided in alternative method) is a negative outcome for water users.
Option 2: Existing methodology in the Plan *Supplementary flow = assessed actual take + allocation block size (which would be 500 l/s)*	• Provides for a larger allocation block size (more water at the supplementary minimum flow) than alternative option.	• Less upfront certainty as the approach will need to be calculated on a consent-by-consent basis. • The larger allocation block size will result in reduced water surety for those within supplementary allocation as it allows for more water to be taken, and hence supplementary minimum flow may be breeched sooner.

5.2. Wakatipu Basin aquifers

Management of the Wakatipu Basin aquifers will be approached via two different management regimes. One approach is to manage the aquifers which have connectivity to a surface water body as surface water. The other approach is to manage aquifers with no connectivity to a surface water body as groundwater, and to set maximum allocation limits to manage the amount of water that can be taken.

5.2.1. Groundwater treated as surface water

There are two options for the aquifers that are to be treated as surface water.

Arrow-Bush Ribbon	**Pros**	**Cons**
Option 1: Listed as a Schedule 2C aquifer tied to the Arrow catchment.	• Consistency across the aquifer is achieved by assessing all water takes as surface water. • Ensures that the amount of water in both the aquifer and the Arrow River is considered together. This then avoids the risk of groundwater takes depleting the river.	
Option 2: Status quo, apply default policies of 6.4.1A(b)&(c).	• Existing policies continue to be applied and allow for investigations at consent stage to be undertaken to demonstrate a differentiation between takes within 100 m and those beyond this.	• Further investigations at a consent stage will need to demonstrate that a groundwater take further than 100 m from the Arrow River, does not have adverse impact on the river, in order to determine the split between groundwater and surface water.
Shotover Alluvial Ribbon	**Pros**	**Cons**
Option 1: Listed as a Schedule 2C aquifer tied to the Shotover catchment.	• Consistency across the aquifer is achieved by assessing all water takes as surface water. • Ensures that the amount of water in both the aquifer and the Shotover River is considered together. This avoids the risk of groundwater takes depleting the river.	• Can't be implemented immediately. Until a minimum flow and allocation regime is put in place for the Shotover River, water takes will continue to be assessed as per the existing policies (Option 2).
Option 2: Status quo, apply default policies of 6.4.1A(b)&(c).	• Existing policies continue to be applied and allow for investigations at consent stage to be undertaken to demonstrate a differentiation between takes within 100 m and those beyond this.	• Further investigations at a consent stage will need to demonstrate that a groundwater take further than 100 m from the Shotover River, does not have adverse impact on the river, in order to determine the split between groundwater and surface water.

Kawarau Alluvial Ribbon	Pros	Cons
Option 1: Listed as a Schedule 2C aquifer tied to the Kawarau Catchment.	• Consistency across the aquifer is achieved by assessing all water takes as surface water. • Ensures that the amount of water in both the aquifer and the Kawarau River is considered together. This then avoids the risk of groundwater takes over depleting the river.	• Can't be implemented immediately - until a minimum flow and allocation regime is put in place for the Kawarau River, water takes will continue to be assessed as per the existing policies (Option 2).
Option 2: Status quo, apply default policies of 6.4.1A(b)&(c).	• Existing policies continue to be applied and allow for investigations at consent stage to be undertaken to demonstrate a differentiation between takes within 100 m and those beyond this.	• Further investigations at a consent stage will need to demonstrate that a groundwater take further than 100 m from the Kawarau River, does not have adverse impact on the river, in order to determine the split between groundwater and surface water.

5.2.2. Maximum Allocation Limit (MAL)

There are two options for the aquifers that are to be treated as groundwater. Essentially there is little difference in the amount of water that would be made available in each of the options. Based on existing science the MAL set in Option 1, is the same amount that would be calculated for 50 per cent of MAR for Option 2. As such, it is a difference of process, rather than a change in the amount that differentiates between the two options.

Morven Aquifer	**Pros**	**Cons**
Option 1: Maximum Allocation limit is listed within the plan Schedule 4A	• Provides clarity by stating upfront an allocation limit of the aquifer. • Reflects up to date science to calculate Mean Annual Recharge. • Is an effective management tool for ensuring the aquifer does not become over-allocated and that the existing state of the aquifer is maintained.	• Limits the flexibility for further investigations to be undertaken to calculate the recharge of the aquifer.
Option 2: Status quo policy 6.4.10A2(b), 50% of MAR.	• Allows for future investigations to be undertaken to determine Mean Annual Recharge, and hence apply an allocation of 50% of whatever MAR is calculated at the time of a consent application.	• Requires further investigations to determine the MAR if a change from the existing science is desired.
Speargrass- Hawthorn Aquifer	**Pros**	**Cons**
Option 1: Maximum Allocation limit is listed within the plan Schedule 4A.	• Provides clarity by stating upfront the allocation limit of the aquifer. • Reflects up to date science to calculate Mean Annual Recharge. • Is an effective management tool for ensuring the aquifer does not become over-allocated and that the existing state of the aquifer is maintained.	• Limits the flexibility for further investigations to be undertaken to calculate the recharge of the aquifer.
Option 2: Status quo policy 6.4.10A2(b), 50% of MAR.	• Allows for future investigations to be undertaken to determine Mean Annual Recharge, and hence apply an allocation of 50% of whatever MAR is calculated at the time of a consent application.	• Requires further investigations to determine the MAR if a change from the existing science is desired.

Upper Mill Creek Aquifer	Pros	Cons
Option 1: Maximum Allocation limit is listed within the plan Schedule 4A	• Provides clarity by stating upfront the allocation limit of the aquifer. • Reflects up to date science to calculate Mean Annual Recharge. • It is an effective management tool for ensuring the aquifer does not become over-allocated and that the existing state of the aquifer is maintained.	• Limits the flexibility for further investigations to be undertaken to calculate the recharge of the aquifer.
Option 2: Status quo policy 6.4.10A2(b), 50% of MAR.	• Allows for future investigations to be undertaken to determine Mean Annual Recharge, and hence apply an allocation of 50% of whatever MAR is calculated at the time of a consent application.	• Requires further investigations to determine the MAR if a change from the existing science is desired.
Mid Mill Creek Aquifer	**Pros**	**Cons**
Option 1: Maximum Allocation limit is listed within the plan Schedule 4A	• Provides clarity by stating upfront the allocation limit of the aquifer. • Reflects up to date science to calculate Mean Annual Recharge. • It is an effective management tool for ensuring the aquifer does not become over-allocated and that the existing state of the aquifer is maintained.	• Limits the flexibility for further investigations to be undertaken to calculate the recharge of the aquifer.
Option 2: Status quo policy 6.4.10A2(b), 50% of MAR.	• Allows for future investigations to be undertaken to determine Mean Annual Recharge, and hence apply an allocation of 50% of whatever MAR is calculated at the time of a consent application.	• Requires further investigations to determine the MAR if a change from the existing science is desired.
Windemeer (Ladies Mile) Aquifer	**Pros**	**Cons**
Option 1: Maximum Allocation limit is listed within the plan Schedule 4A	• Provides clarity by stating upfront the allocation limit of the aquifer. • Reflects up to date science to calculate Mean Annual Recharge.	• Limits the flexibility for further investigations to be undertaken to calculate the recharge of the aquifer.

	• It is an effective management tool for ensuring the aquifer does not become over-allocated and that the existing state of the aquifer is maintained.	
Option 2: Status quo policy 6.4.10A2(b), 50% of MAR.	• Allows for any future investigations to be undertaken to determine Mean Annual Recharge, and hence apply an allocation of 50% of whatever MAR is calculated at the time of a consent application.	• Requires further investigations to determine the MAR if a change from the existing science is desired.
Frankton Flats Aquifer	**Pros**	**Cons**
Option 1: Maximum Allocation limit is listed within the plan Schedule 4A	• Provides clarity by stating upfront the allocation limit of the aquifer. • Reflects up to date science to calculate Mean Annual Recharge. • It is an effective management tool for ensuring the aquifer does not become over-allocated and that the current health of the aquifer is maintained.	• Limits the flexibility for further investigations to be undertaken to calculate the recharge of the aquifer. Currently there is a limited understanding of the relationship between Frankton Flats Aquifer and the Lake Wakatipu, Kawarau and Shotover Rivers surface flows. MAR has been calculated using rainfall as the only source of recharge.
Option 2: Status quo policy 6.4.10A2(b), 50% of MAR.	• Allows for any future investigations to be undertaken to determine Mean Annual Recharge, and hence apply an allocation of 50% of whatever MAR is calculated at the time of a consent application.	• Requires further investigations to determine the MAR if a change from the existing science is desired.
Fitzpatrick Aquifer	**Pros**	**Cons**
Option 1: Maximum Allocation limit is listed within the plan Schedule 4A	• Provides clarity by stating upfront the allocation limit of the aquifer. • Reflects up to date science to calculate Mean Annual Recharge. • It is an effective management tool for ensuring the aquifer does not become over-allocated and that the current health of the aquifer is maintained.	• Limits the flexibility for further investigations to be undertaken to calculate the recharge of the aquifer
Option 2: Status quo policy 6.4.10A2(b), 50% of MAR.	• Allows for any future investigations to be undertaken to determine Mean Annual Recharge, and hence apply an allocation of 50% of whatever MAR is calculated at the time of a consent application.	• Requires further investigations to determine the MAR if a change from the existing science is desired.

Reference list

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2. Goodman, JM., Dunn, N. R., Ravenscroft, P. J., Allibone, R. M., Boubee, J.A. T., David, B. O., Griffiths, M., Ling, N., Hitchmough, R A., & Rolfe, J. R. (2014). *Conservation Status of New Zealand Freshwater Fish*, 2013. New Zealand Threat Classification series 7, 12 p. Wellington, New Zealand: Department of Conservation.
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