DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

Annual plan for the Snowy and montane rivers increased flows 2021–22

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Abbreviations

ML	Megalitre
GL	Gigalitre
SFRMM	Snowy Flow Response Monitoring and Modelling program
SMRIF	Snowy montane rivers increased flows
SRIF	Snowy River increased flows
SWI	Snowy Water Initiative
SWIOID	*Snowy Water Inquiry Outcomes Implementation Deed 2002*

Introduction

This watering plan was developed by the Environment, Energy and Science Group in the NSW Department of Planning, Industry and Environment and incorporates advice from the Snowy Advisory Committee.

This annual plan outlines the rationale and intention for use of water for the environment for the Snowy and Snowy montane rivers for the 2021–22 water year (1 May 2021 to 30 April 2022), and gives effect to the NSW Government's commitment to implement the Snowy Water Initiative (SWI) on behalf of the partner governments.

The SWI was formally established in 2002 to significantly improve river health by releasing environmental water into the Snowy, upper Murrumbidgee and upper Murray river systems. Embodied in the *Snowy Water Inquiry Outcomes Implementation Deed 2002* (SWIOID 2002), the SWI is an agreement for water recovery and environmental flows between the NSW, Victorian and Australian governments (the 'partner governments') and Snowy Hydro Limited. The NSW Government is responsible for the implementation of the SWI.

Environment, Energy and Science Group manages water for the environment in the Snowy and Snowy montane rivers on behalf of the NSW Government. Environmental releases to the Snowy River are to deliver an average of 212,000 megalitres (ML) or 21% of the average annual natural flow. When low water allocations are available in the western Murray–Darling Basin water storages, there is less water available for the Snowy and Snowy montane rivers.

The SWI provides for three increased environmental water flow regimes to adjust for the diversion of river flows by the Snowy Hydro-electric Scheme:

1. **Snowy River increased flows** (SRIF) – environmental water to be released every day from Jindabyne Dam to improve the health of the Snowy River in New South Wales and Victoria; average 212,000 ML annual flow target (Figure 1)
2. **Snowy montane (higher altitude) rivers increased flows** (SMRIF) – environmental water to be released continually or according to an annual schedule from a number of designated release points across certain rivers diverted by the Snowy Mountains Scheme (Figure 2) in a quantity proportional to the amount allocated to the Snowy River below Jindabyne; up to a maximum of 150 gigawatt hours (GWh) each year
3. **River Murray increased flows** – water allocation accruing up to 70,000 ML in the Murray River system that is callable by environmental water holders for delivery into the Murray River.

River Murray increased flows are managed in an integrated manner with other environmental water allocations by the Southern Connected Basin Environmental Water Committee and are not covered in this plan.

For the 2021–22 water year, 201,077 ML of water for the environment is available as SRIF, and a volume of water equivalent to 142.272 GWh of foregone energy generation will be available as SMRIF. With wetter conditions in the southern Murray–Darling Basin, the water allocation for 2021–22 is significantly higher than the 91.4 GL that was available last water year.

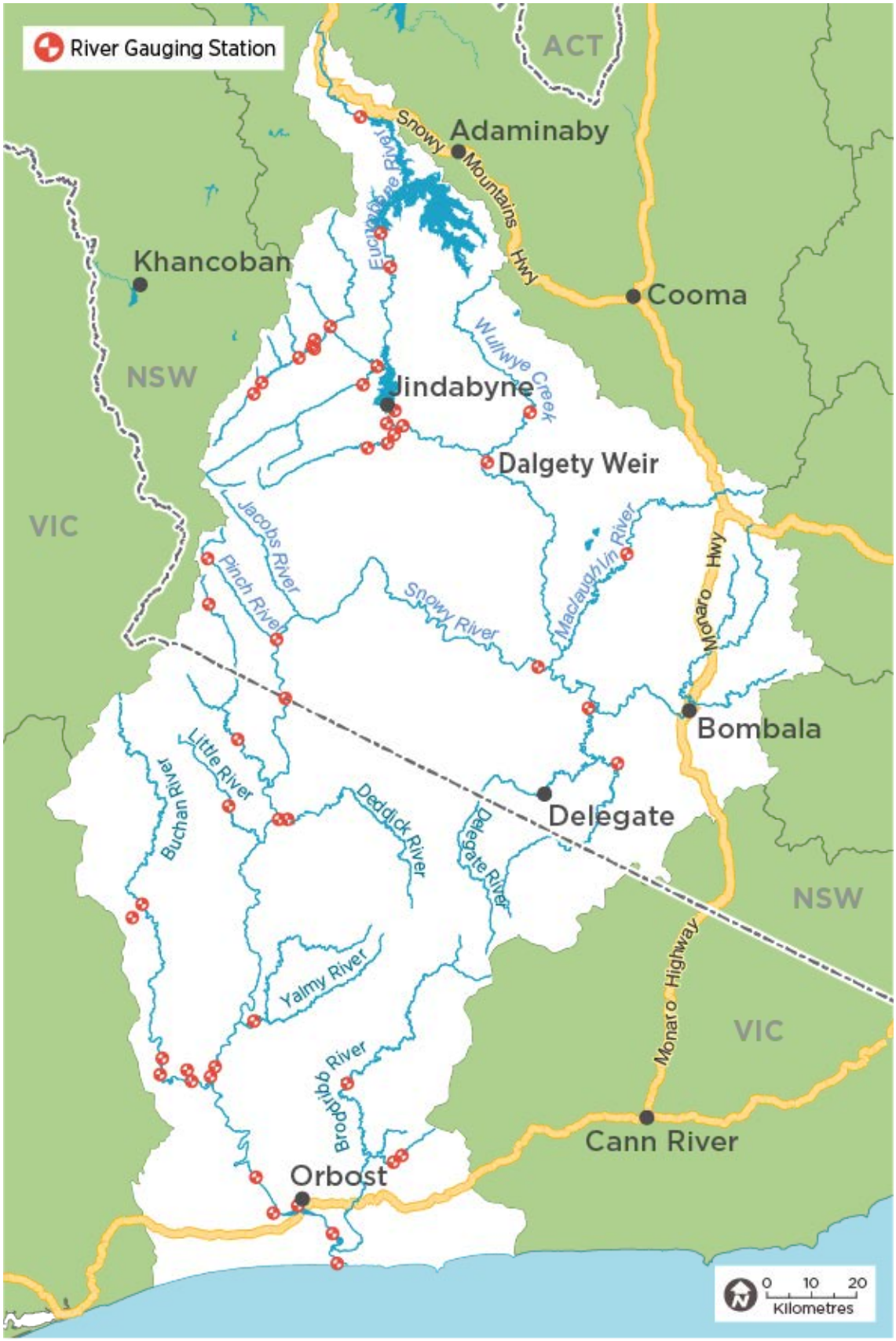

Figure 1 **The Snowy River catchment in south-eastern Australia, showing the location of Jindabyne Dam, major tributaries and hydrological gauging stations**

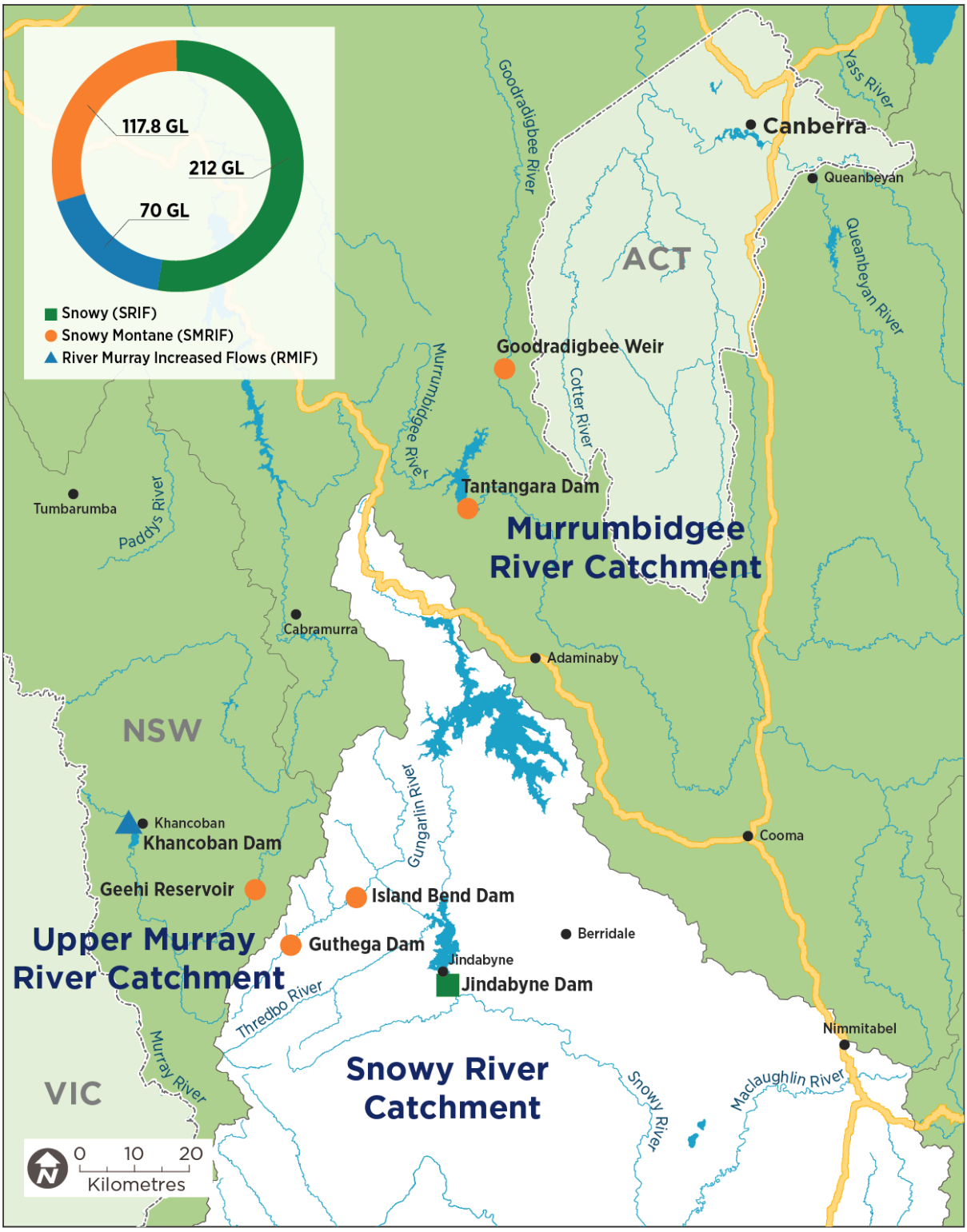

Figure 2 **Locations of the Snowy montane rivers water release points, indicated by orange icons, and a pie chart of maximum annual flow volumes for the three increased flows**

Natural flow scaling of Snowy River increased flows

A ‘natural flow scaling approach’ (Reinfelds et al. 2013) has been used to deliver environmental water to the Snowy River below Jindabyne Dam since 2013–14, when 212,000 ML of water entitlement for the Snowy River was achieved for the first time under the SWI.

The volume of water available for environmental flows in the Snowy River is approximately equivalent to annual natural flows in the Thredbo River. The Thredbo River is not regulated by dams, so its flow pattern is still close to natural. A practical interim objective using the natural flow scaling approach has been to deliver a flow regime that, over the long term, will drive the hydraulic geometry of the Snowy River below Jindabyne Dam to be more like the Thredbo River as river channel sediment is mobilised and redistributed.

The primary advantage of natural flow scaling is that the pattern of the flow regime is proportional to the volume of available environmental water. Peak flood magnitudes and duration can be tailored to achieve flow transmission and ecosystem objectives, while the flow regime mimics daily, seasonal and annual patterns in flow variability. This approach also provides a secure operational flow forecast that Snowy Hydro Limited can plan for and deliver.

The natural flow scaling approach recognises that with only 21% of the natural flow available, restoring any single aspect of the pre-regulation Snowy River flow regime could compromise other aspects of the flow regime and not optimise river health. Even the lowest annual discharge recorded in the Snowy River at Jindabyne before the dam and river diversion is approximately double the total volume of water available for environmental flows (Reinfelds et al. 2013).

Snowy River. Photo: Rob Gibbs/DPIE

Snowy River increased flows in 2021–22

Snowy River increased flows (SRIF) annual allocations are determined by inflows into the western catchment storages where Snowy Water savings projects and market purchases were implemented to secure various water entitlements. These projects, funded by the NSW and Victorian governments, obtained water shares that were then transferred to Snowy environmental water licences. The water allocated to the SRIF licences in one year is then made available for environmental releases from Snowy storages in the following year. Planning for the forward year commences around November of each year, when the indicative volume of water available on the licences can be forecast with some certainty.

There is 201,077 ML of water for the SRIF licences for 2021–22, which is 95% of the mean annual targeted flow for releases of 212,000 ML below Jindabyne Dam (Table 1). There is sufficient environmental water available to implement a natural flow scaling pattern.

Note: The SRIF amounts add to a base passing flow amount of 8500 ML released from Jindabyne Dam. Adjustments of the base passing flow amount are required when the amount of water released in the previous year was more than (‘overs’) or less than (‘unders’) the agreed flow volume. That amount is then corrected with changes to actual releases in the following year by reducing or increasing the 8500 ML figure.

Table 1 Summary of annual water allocation for the Snowy River for 2021–22

Water account	Annual volume (ML)
Snowy River increased flows	201,077
Base passing flow – Jindabyne	8,500
Subtotal	209,577
Overs/Unders	300
Total	**209,877**

The 2021–22 water year will be the ninth consecutive year that the natural flow scaling approach has been used to develop the environmental water release strategy for the Snowy River below Jindabyne. The 2021–22 SRIF daily flow sequence is based on the 1998–99 water year in the Thredbo River, which had 187,000 ML yearly flow. The 1998–99 water year was chosen as the reference because it had the highest peaks and a good range of peaks spread across winter and spring. However, this reference year had low flows and limited variability for some periods of the year. To improve the environmental outcomes for the Snowy River, the remaining 23,000 ML will be delivered during the lower flow periods during May to June in 2021 and in April 2022 using the 1988–89 water year as the reference.

The 2021–22 flow plan is shown in the hydrograph below (Figure 3). There are nine high-flow events peaking above 2000 ML/day. Five of these high flows have eight-hour peaks including one flushing flow above 5000 ML/day. These releases will require active management by Snowy Hydro Limited to generate the eight-hour peaks and reach the overall daily targets.

The high peak flows of this regime will provide increased stream power to flush sediment from the stream bed, and the repeated pattern of several peaks is expected to help keep the sediment moving.

Fine sediment and sand are known to move at discharge rates of >1000 ML/day in the upper reaches of the Snowy River (Williams 2010). While longer peak durations provide greater sediment movement than shorter peaks (Rose 2017), monitoring indicates that most of the fine sediment is moved in the first few hours of the releases (Coleman & Williams 2017; Coleman, unpublished data). The high flows for the Snowy River are therefore short in duration and in line with the natural Thredbo flows, with a maximum peak held for eight hours for the majority of the highest flows.

Coleman and Williams (2017) also found that the greater the increase in magnitude and interval since the previous high flow, the greater the amount of sediment moved by the high flow. The proposed flow regime for 2021–22 provides a number of separate high flows, many with intervals of several weeks since the last event, and with a general trend of flows increasing up to the maximum peak of early October 2021.

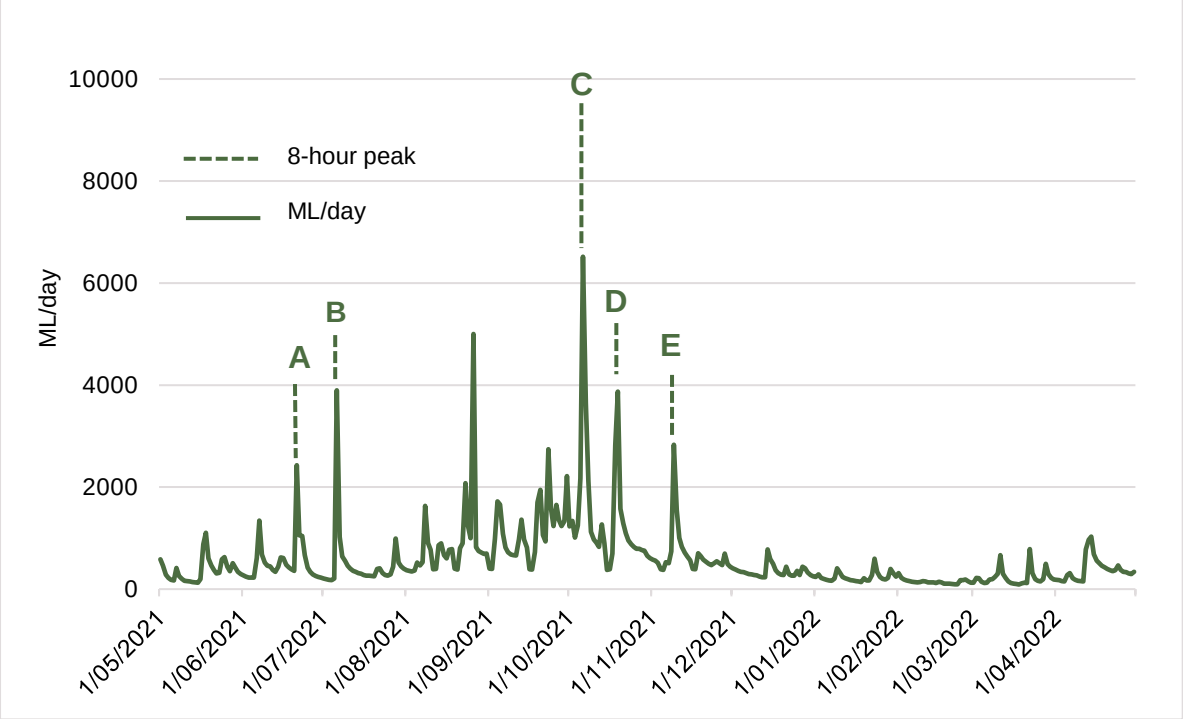

Figure 3 **Snowy River below Jindabyne Dam mean daily discharge pattern for 2021–22, with five eight-hour flow peaks (A, B, C, D, E)**

Note flows exceed 2000 ML/day in four other events

The five flows with eight-hour peaks are:

Peak	Date	Daily peak (ML/day)	8-hour peak (ML/day)
A	21 June 2021	2,431	4,107
B	6 July 2021	3,900	5,000
C	6 October 2021	5,516	10,362
D	18 October 2021	3,871	4,699
E	9 November 2021	2,831	4,263

Figure 4 summarises the total monthly discharge patterns for 2021–22 below Jindabyne Dam. A pattern of higher flow rates over winter and spring reflects the winter rainfall/runoff patterns typical of a mixed rainfall and snowmelt river system characteristic of the Snowy Mountains.

Low flows will occur during the natural low-flow periods of summer and autumn, with higher energy flows in spring for river channel recovery.

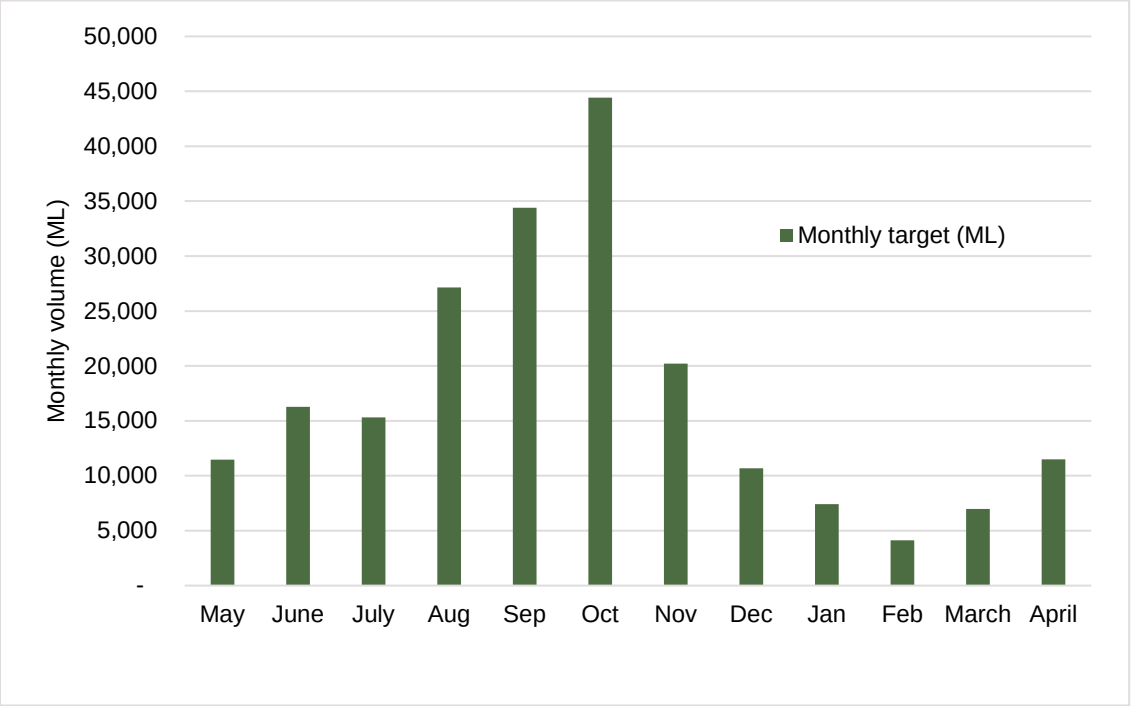

Figure 4 Snowy River below Jindabyne Dam total monthly discharge pattern for 2021–22

Natural tributary inflows below the junction with the Delegate River are expected to provide the most substantial contribution to the flow regime and ecosystem processes of the lower reaches of the Snowy River and its estuary in this water year.

Objectives for Snowy River increased flows

In determining how to use water for the environment in the Snowy River below Jindabyne Dam, the partner governments agreed that a primary ecological objective would be achieved by storing and then releasing sufficient volumes to provide annual flushing flows and occasional channel maintenance flows.

Flushing flows scour and transport finer sediment (sand, silt and clay) and improve the physical condition of the in-stream river channel habitat and overall river health.
Channel-forming flows scour larger sediments (gravel and cobbles) and define a channel pathway within the overall river bed. It is expected that as the river physically responds over time to these higher energy flows, the recovery process can transition to meet other secondary ecological objectives.

The SWIOID 2002 sets out five key environmental objectives for the SRIF:

1. improving the temperature regime of river water
2. achieving channel maintenance and flushing flows within rivers
3. restoring connectivity within rivers for migratory species and for dispersion
4. improving triggers for fish spawning
5. improving the aesthetics of currently degraded riverine environments.

The Department of Planning, Industry and Environment – Water redefined the SWIOID objectives, incorporating new knowledge and scientific information to better define the aspects of riverine health that are key to the recovery of a geomorphologically confined Snowy River (Williams 2016a). As aquatic plants and animals are adapted to local climatic and hydrological conditions, being able to represent the varied characteristics of the local hydrology is therefore a key driver to river recovery from flow diversion.

The redefined overarching objective is:

To facilitate the rehabilitation and evolution of the Snowy River below Jindabyne Dam into a smaller but healthy montane river.

The specific objectives are summarised below:

1. **Hydrology** – provide the natural hydrological characteristics of a smaller but unregulated montane river (including seasonality, daily variability and high flows).
2. **Channel morphology** – develop a more defined river channel within the former river channel.
3. **Riverbed maintenance and nutrient translocation sites** – reduce fine sediment and algae smothering, increase clean substrate including cobbles and gravels.
4. **Basal resources** – enhance delivery of complex dissolved organic carbon and other basal resources, increase frequency of events that inundate lower in-channel river benches.
5. **Riverine and aquatic vegetation** – limit the encroachment of terrestrial plants into the river channel and establish native aquatic and riparian vegetation.
6. **Thermal regime** – provide a thermal regime similar to an unregulated montane river.
7. **Benthic aquatic macro-invertebrate communities** – increase the abundance of aquatic invertebrate fauna commonly found in unregulated Snowy montane rivers with gravel and cobble substrate.
8. **Fish assemblages** – reflect the more diverse native fish community composition of the unregulated tributaries in the main channel of the Snowy River.
9. **Dispersal of native fish** – increase opportunities for localised and (where possible) larger scale movements.
10. **Platypus** – provide increased opportunities for movement and feeding.
11. **Estuary health** – see below.
12. **Aesthetics** – ensure water clarity, clean substrates, defined river channel and complex riparian native vegetation.
13. **Cultural recognition** – inform Aboriginal stakeholders, improve cultural recognition and representation, link cultural and environmental water objectives where appropriate and integrate traditional knowledge.

With new information available, the **estuary health** objective has been superseded by Hale (2020) who provided draft objectives summarised below:

- improve the temperature regime of the estuary
- restore connectivity and maintain estuary entrance opening
- improve conditions and productivity of the estuary and wetlands to support native fish, including spawning and recruitment.

Inflows have been significantly higher than the previous year due to wet conditions in the southern Murray–Darling Basin. With the wetter conditions many of these objectives can be achieved to improve ecological health, condition and resilience of water-dependent ecosystems (MDBA 2020).

The focus of the flow regime for 2021–22 is to:

- improve channel condition by providing several flushing flows
- support diverse habitats
- increase resource availability and biological productivity to support aquatic plants and animals
- enhance biological reproduction and recruitment for native water-dependant species, including water bugs, frogs and fish
- increase connectivity and dispersal within and along the river channel.

Snowy River, Main Range walk. Photo: Elinor Sheargold/DPIE

Snowy montane rivers increased flows

The SWIOID 2002 also provides for environmental releases into a number of higher altitude (montane) rivers whose flows are significantly affected by the operation of the Snowy Hydro-electric Scheme. These are known as the Snowy montane rivers increased flows (SMRIF) allocation. The environmental water is released from small weirs as a passing flow, or as managed releases from Tantangara Dam for the following rivers (see Figure 2):

- Snowy River above Jindabyne Dam
- Goodradigbee River
- Murrumbidgee River below Tantangara Dam
- Geehi River.

Each water release point results in a different amount of foregone generation potential for Snowy Hydro Limited for each megalitre of water that is released, up to a maximum of 150 gigawatt hours (GWh) each year.

Each year, the degree to which generation is foregone by Snowy Hydro Limited is proportional to the volume of environmental water allocated to the Snowy River. If the average 212,000 ML target is available for the Snowy River, the full 150 GWh of generation potential equivalence will be allocated to the montane rivers. As the water is either re-regulated by the Snowy Scheme, or by water supply storages in the western rivers, we do not need additional water savings to enable these releases.

All of the targeted release points have required modification to existing diversion works to allow us to make the releases. This was undertaken progressively as the SRIF water licences accrued up to 212,000 ML.

Releases to the upper Murrumbidgee River are made from Tantangara Dam, a much larger structure than the other release points. Tantangara releases usually comprise two components: a SMRIF amount, plus a required annual base passing flow.

The Tantangara base passing flow has two key operating rules required by the Snowy Water Licence:

- 32 ML/day minimum river discharge maintained at Mittagang Crossing, near Cooma
- 2000 ML/year volume on average is targeted over the longer term.

Montane releases from the other, smaller weirs reflect the catchment inflows to each weir pool and it is not practical to prescribe a daily flow target. The downstream flow from the smaller weirs reflects the hydrology of their inflows where, in wetter years, the flow will exceed the long-term target and, in drier years, the annual volume will be less than the target.

The SMRIF sets an annual yield so that over the long term the annual volume will approximate the nominated increased flow target. To achieve the long-term target, each weir has been modified to either allow all water to pass downstream (known as ‘transparent releases’), or in the case of the Goodradigbee River, allow a proportion of the daily inflows to pass downstream (known as ‘translucent’ releases). This is so that the flow characteristics downstream of the modified weirs will reflect the hydrology of a smaller mountain river or stream.

The volumes identified on the pie chart in Figure 2 represent the 212,000 ML allocation scenario (21% of the average natural flow).

Snowy montane rivers increased flows in 2021–22

The SRIF allocation for 2021–22 will lead to a foregone generation value of 142.272 GWh for SMRIF. There is sufficient allocation to operate all the weirs of the montane program and provide 31,800 ML of environmental water to be released from Tantangara Dam into the upper Murrumbidgee River. This includes allowing full flow over Middle Creek Weir and the maximum flow over the Goodradigbee Weir.

The SMRIF allocations for each river reach and the works to deliver the environmental water are identified in Table 2.

Similar to the Snowy River, when there is sufficient environmental water available, a modified 'flow scaling' approach has been applied to the Murrumbidgee River to assist in providing natural seasonality and daily variability. This approach uses historical flows from the gauge on the Murrumbidgee River above Tantangara as a reference. For the 2021–22 daily flows, the 1998–99 flow pattern has been used as a reference because it includes a good range of flow peaks across the winter–spring season.

The natural flow pattern of the upper Murrumbidgee River varies from that of the Snowy River, as there are strong climatic gradients across the Snowy Mountains. Typically, the upper Murrumbidgee River catchment is lower in elevation than the Snowy River catchment and has substantially less catchment area above the snowline, therefore snowmelt flow is not as pronounced as in the Snowy River.

Table 2 Snowy montane river increased flow allocations and settings for the 2021–22 water year

River reach/ catchment	Modified works	Conversion factor (GWh per GL)	Forgone electricity generation (GWh)	2021–22 volume (GL)	SWIOID annual target (GL)
Murrumbidgee River	Tantangara Dam outlet	1.94	61.6	31.8	27
Goodradigbee River	Goodradigbee River Weir	1.94	23.3	12	12
Geehi River	Middle Creek Weir	1.85	32.4	17.5	20
	Strzelecki Creek Weir	1.85	9.6	5.2	
Snowy River – Island Bend to Lake Jindabyne	Tolbar Creek Weir	0.71	6.7	9.5	20
	Diggers Creek Weir	0.71	6.7	9.4	
Snowy River – Guthega to Island Bend	Falls Creek Weir	0.57	1.9	3.4	30
Total			**142.3**	**88.8**	**118**

The upper Murrumbidgee flow pattern set out in Figure 5 will allow for:

- daily flow variability from late May to the end of December 2021 to reflect a scaled natural flow pattern
- three daily high-flow peaks above 1000 ML to flush sediment and inundate benches. The highest of these is 1500 ML/day. Although the peaks are accentuated, they are still smaller than the 'pre-scaled' size of the original Murrumbidgee above Tantangara flows (highest peak in 1998–99 reference year was 2450 ML/day).

- a small peak in January 2022 after one week of zero flows to support the migration of Macquarie perch back to refuge pools
- a final small peak in April to promote productivity and produce food for native animals and plants.

There will be no environmental flow released from Tantangara for three periods totalling 108 days as there is insufficient water available to maintain the flow regime for every day of the year. During this time, Snowy Hydro Limited is required to make releases to maintain flows at or above 32 ML/day at Mittagang Crossing if tributary flows do not provide this level of flow.

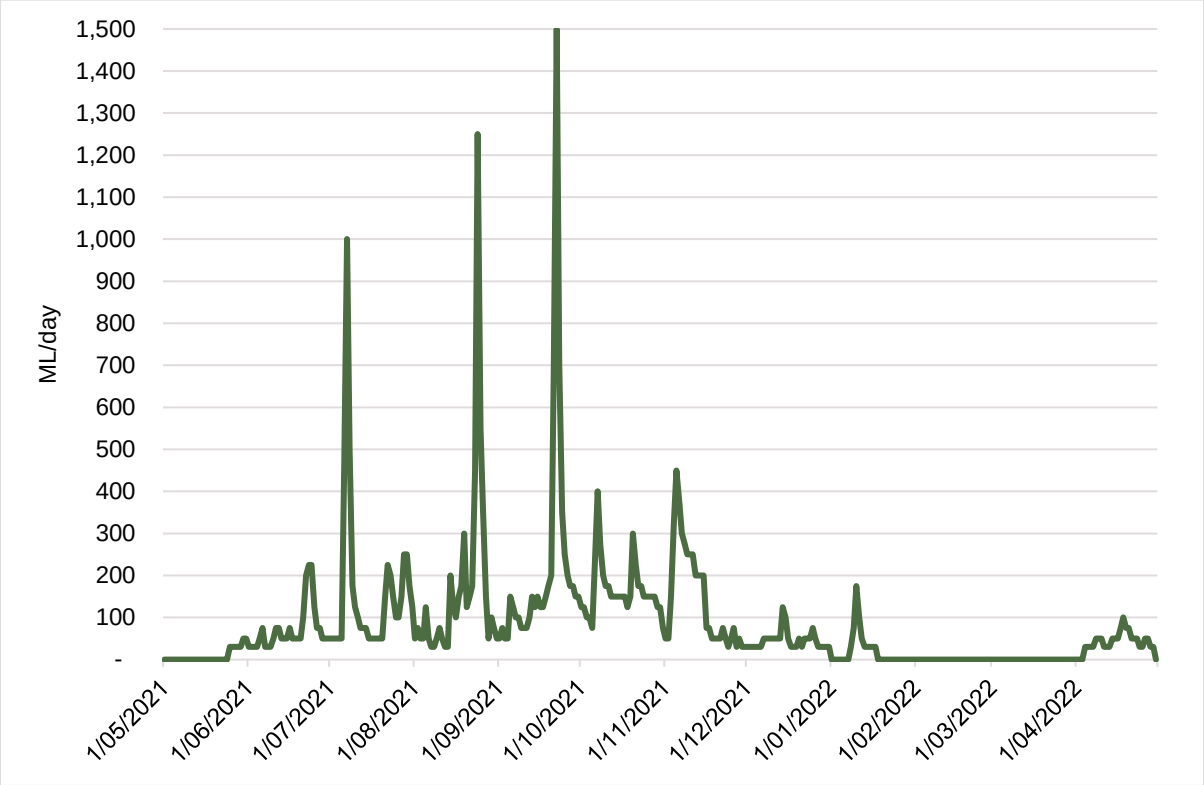

Figure 5 **2021–22 Snowy montane rivers increased flow pattern for the upper Murrumbidgee River below Tantangara Dam**

Objectives for Snowy montane rivers increased flows

The SWIOID 2002 set the following ecological objectives for the Snowy montane rivers:

1. to protect endangered/ threatened species
2. to maintain natural habitats
3. to maintain wilderness and national parks values.

Using newly available knowledge and scientific information, the Department of Planning, Industry and Environment – Water refined the objectives as follows (Williams 2016b):

1. provision of substantially increased wetted in-stream habitat, and the river channel better reflecting the natural hydraulic characteristics of a montane river
2. a thermal regime that better reflects a montane river
3. regular scour of the river substrate
4. improved hydrological and ecological connectivity along the water source
5. reduction in the ingress of terrestrial vegetation in the channel, such as tea-tree
6. establishing and maintaining the ecological communities (i.e. benthic bacteria, periphyton, aquatic plants, bugs and fish) that reflect those of a Snowy montane river.

For the Murrumbidgee River specifically, the following overarching objective has also been identified:

To facilitate the rehabilitation and evolution of the Murrumbidgee River below Tantangara Dam into a smaller but healthy river.

The daily releases from Tantangara into the upper Murrumbidgee has three peaks of 1000 ML/day or greater to help move sediment, clean riffles and reduce encroachment of vegetation.

The endangered Macquarie perch is present downstream of Yaouk. Macquarie perch spawn from October to December and their eggs lodge in gravel and cobble in riffles (Lintermans 2007). The three high-flow releases are timed to flush gravels and cobbles prior to the breeding season to provide a better substrate for the eggs and successful breeding.

Improved habitat via flushing and improved productivity are expected to provide benefits for a range of biota, including macro-invertebrates in the upper Murrumbidgee. Improved populations of macro-invertebrates in turn provide food for platypus, fish, frogs and other all animals.

River near Island Bend. Photo: John Spencer/DPIE

Monitoring of SRIF and SMRIF

Monitoring, evaluation and reporting will inform planning and use of Snowy and montane environmental water.

In 2000 the NSW Government established the Snowy Flow Response Monitoring and Modelling (SFRMM) program to assess the changes in river condition attributed to the environmental flows. The monitoring parameters included hydrology, geomorphology, macro-invertebrates, aquatic vegetation, water quality, productivity (biofilm, algae, carbon) and fish.

Elements of the SFRMM program were initially funded by the NSW, Victorian and Australian governments. A large portion of the monitoring effort until 2012 primarily focused on the Snowy River and included geomorphology, water quality, hydrology, fish and macro-invertebrates studies. In the montane rivers the focus was on macro-invertebrate response to environmental flows.

Smaller biannual macro-invertebrates studies in the Snowy and montane rivers have been continued, with other monitoring undertaken opportunistically, including studies on fine sediment mobilisation and assessment of changes to the Snowy River channel and vegetation.

Table 3 is a framework for monitoring of outcomes against SRIF and SMRIF objectives that will be developed by Environment, Energy and Science Group in the Department of Planning, Industry and Environment with the advice of relevant experts.

With the annual watering plan complete, the monitoring framework can be refined with input from the Snowy Advisory Committee and experts.

Table 3 Framework example for monitoring outcomes against SRIF and SMRIF objectives

Parameter	Site	SWIOID objective: Snowy	SWIOID objective: montane	Williams (2016a) objective: Snowy	Williams (2016b) objective: montane
Fish	Upper Murrumbidgee		Objective 1		Objective 6
Frogs	Snowy River (Dalgety Plains), upper Murrumbidgee River				Objective 6
Geomorphology	Snowy River	Objective 2	Objective 2	Objectives 2 & 3	
Hydrology (water volumes delivered, tributary inflows)				Objective 1	
Macro-invertebrates	Montane rivers, Snowy River			Objective 7	Objectives 4 & 6
Vegetation	Snowy River, upper Murrumbidgee River		Objective 2	Objective 5	
Water quality (electrical conductivity, pH temperature)	Montane, Snowy River	Objective 1		Objective 6	

Social, cultural and economic considerations

The Snowy and Snowy montane rivers are of great significance for their connection to a range of communities and people. This has remained a driving force behind the actions that have led to their ongoing recovery.

It is important the key linkages and dependencies of communities and people to the mountain rivers are recognised and, where possible, nurtured by the effective use of environmental water. These understandings will grow with increased knowledge of traditional and contemporary practices of the First Peoples' movements following seasonal travel routes and the availability of food and resources.

The Snowy Advisory Committee established by the NSW Government will be a primary source of advice to water managers on these relationships: cultural, social or economic. The committee has resolved to develop a framework for future advice that will support decisions that are broader in application than annual flow scaling.

Consistent with the statutory basis of the committee, it will seek to provide advice for the SRIF and SMRIF allocations that is first and foremost about what is best for the environment, but that can also achieve cultural, social and economic benefits where they are compatible with achieving environmental outcomes. The committee considers that multiple benefits should be sought when providing its advice. Most importantly, the committee considers that the framework must be inclusive of Aboriginal culture and heritage and this aspect will be included in all advisory considerations.

Over time, the committee considers that integrating these objectives will guide more detailed and nuanced flow management and monitoring activities. These understandings will grow around the central concepts of the rivers and their First Peoples, with an intention to provide for healthy rivers that support a diversity of cultural, social and economic activity.

Healthy rivers recovered from a history of water diversion will remain the primary purpose of water use. The direction set by the committee will, however, lead to better identification of river-use constraints with the intention that water managers will better communicate plans and, where possible, optimise multiple benefits for river-use objectives such as the availability of water for recreational activities.

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