Environmental Releases from Jindabyne Dam: Recommendations for 2009-2010

Snowy Scientific Committee

June 2009

Canberra

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Prepared for the

Water Ministerial Administration Corporation of New South Wales

Cover Photographs

Top: near Dalgety, 30 September 2008.

Below: Byadbo Creek inflow, 29 June 2007, during a medium flow event.

Photographs provided by Southern Rivers CMA.

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Section 1: Purpose and Scope

1.1 Purpose

One of the principal functions of the Snowy Scientific Committee (SSC), which is specified in Paragraph 57(3) of the Snowy Hydro Corporatisation Act 1997, is *to advise the Water Administration Ministerial Corporation each year on the regime for the release of water for environmental reasons under the Snowy Water licence.*

The Snowy Water Licence, as issued on 30 May 2002, under Part 5 of the Snowy Hydro Corporatisation Act 1997 (NSW), requires Snowy Hydro Limited (SHL) to release from Jindabyne Dam into the Snowy River a volume of water specified by the Water Administration Ministerial Corporation (WAMC), in a temporal pattern specified by WAMC. Snowy Hydro Limited is also required to release from Tantangara Dam a volume of water specified by WAMC, in a temporal pattern specified by WAMC. In both instances, if no such advice is received, a default provision applies: this default is specific to each Dam.

Under the Snowy Hydro Corporatisation Act, the Snowy Scientific Committee is expected to make recommendations each year to WAMC on the pattern of environmental releases for two systems: from Tantangara Dam to the upper Murrumbidgee River, and from Jindabyne Dam to the Snowy River. The volume available for environmental releases is determined by the relevant water authorities in NSW and Victoria, following the processes detailed in the Snowy Water Inquiry Outcomes Implementation Deed (SWIOID 2002) and summarised as Five Steps in Appendix 1.

1.2 Scope

The purpose of this report is to submit recommendations to WAMC on the pattern of release from Jindabyne Dam to the Snowy River for the water year 2009-2010, taking into account the volume available, the state of the Snowy River and the recent climate conditions. These recommendations are specific to this particular water year and for the volume available. In no way should these recommendations be construed as generic advice on water releases to the Snowy River downstream of Jindabyne Dam.

For 2009-2010, the Snowy Scientific Committee has restricted its advice to Snowy River Increased Flows (SRIF) which are the releases from Jindabyne Dam.

Releases from Tantangara Dam are part of the Snowy Montane Rivers Increased Flows (SWIOID 2002) which are also to be considered by the Snowy Scientific Committee. For this coming water year only, the pattern for releases from Tantangara Dam is being determined by scientists within the NSW Department of Water and Energy so are not included here.

Section 2: Outline of Approach

2.1 Role of the Snowy Scientific Committee

The original environmental flow recommendation for the Snowy River below Jindabyne, as devised by the Expert Panel in 1995 (Pendlebury *et al*. 1996), remains the basic overall vision for delivery of environmental flows. The agreed current target is to reach 212 GL by 2012 which, with 9 GL base passing flow, is equivalent to 21% of average natural flow, with the possibility of as much as 294 GL if the parties are willing and the necessary agreements can be reached (SWIOID 2002). The extensive annual monitoring by Snowy River Flow Response Monitoring and Modelling program, initiated in 1998, documented the abiotic and biotic condition of the Snowy River from Jindabyne to Orbost prior to the implementation of the required environmental flows, and has continued since. This monitoring has provided an excellent broad-based data base by which the changes in the river through the advent of environmental flows can be rigorously assessed. The implementation of the Snowy River environmental flow project is one of the very few such projects in Australia with a solid data base across control sites, reference sites and the targeted river prior to flow implementation, which can then be used to assess the impacts of the environmental flows.

With the formation in May 2008 of the Snowy Scientific Committee and with continued monitoring, informed annual adjustments to the environmental flow can be made once the volume of water for any particular year has been estimated. The links between environmental flow releases and monitoring data will allow the SSC to adaptively manage the nature of the environmental flows. This is preferable to the inflexible (and more common) approach of being tied to a set of pre-determined guidelines. As a branch of applied stream ecology, knowledge of the impacts of environmental flows is rapidly building (e.g., Poff *et al*. 2006, Arthington *et al.* 2006) and through the SSC and based on the monitoring data, new approaches may be drawn into the overall environmental flow implementation. Furthermore, stochastic events or disturbances, such as bushfires, may occur and have damaging effects on the Snowy River system. Armed with site-specific knowledge of impacts from the Flow Response Monitoring Program, the SSC will be well placed to devise new procedures to offset these impacts and safeguard the river.

On the other hand, making recommendations annually, and in advance, may limit the implementation of desired changes in flow to alleviate the effects of severe

disturbances, and may also limit the possibility of supplementing and managing opportunistically natural high flow events when and if they occur. A framework and mechanisms for within-year adaptive management of environmental releases is an area yet to be collectively addressed by the Snowy Scientific Committee, Department of Water and Energy, and Snowy Hydro Limited.

2.2. Conceptual Approach

In recent years there has been a surge of scientific research, both in Australia and overseas, on the effects that flow regimes have on the hydrology, geomorphology, and ecology of rivers. This research effort has produced a basic and insightful understanding of how rivers operate in an ecologically sustainable way, and of how changes to the flow regime may degrade the integrity of riverine ecosystems (eg. Arthington *et al*. 2006). Thus, in formulating the flow regime for the Snowy River below Jindabyne, the SSC can draw on a rich and cohesive body of scientific literature and principles.

There is now widespread agreement that there are five key components of natural flow regimes in flowing waters (Poff *et al.* 1997). These are (1) the volume of flow, (2) the frequency of occurrence of flow events, (3) the duration of flow events, (4) the predictability of flow events, and (5) the rate of change or flashiness of flows (Poff *et al.* 1997). The flow regime of a river can be characterized by the nature of these components and it is to the combination of these components in natural rivers to which flora and fauna have adapted (Lytle and Poff 2004). Arising from the natural flow components and the adaptations of the biota, there are clearly four major principles that emerge when considering flow and river ecosystems (Bunn and Arthington 2002). Specifically, in terms of biodiversity and ecological processes, these four principles are:

> Principle 1: Flow is a major determinant of the physical habitat in streams.
>
> Principle 2: Aquatic species have evolved life history strategies primarily in direct response to the natural flow regime.
>
> Principle 3: Maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of many riverine species.
>
> Principle 4: The invasion and success of exotic and introduced species is facilitated by the alteration of flow regimes.

In altering the flow regimes of rivers by changing any one or a combination of the five key components of the flow regime of a natural river, the potential to degrade the river ecosystem is greatly increased. This degradation results from significant alteration of some or all of the four principles listed above.

These principles have been substantially incorporated into the environmental flow principles of the NSW Department of Water and Energy (see below).

Environmental rules for rivers

The following diagram (Figure 1) illustrates, in general terms, the importance of different flow ranges to a river's environment: Low, Moderate, Freshes and Floods. Note that by drawing the curve from 100% to about 3-4%, that the importance of 'true floods' (ie flow durations less than 3-4%) is overlooked.

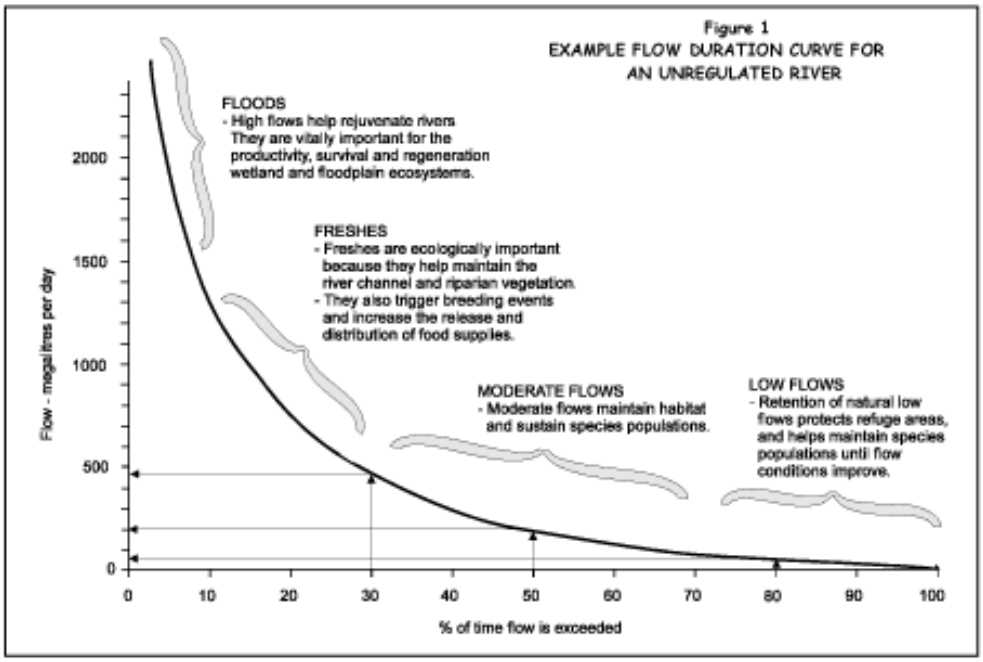

Figure 1: Flow ranges and river ecology

Schematic diagram summarising the importance of different flow ranges, approximately categorised as floods, freshes, moderate and low flows, from DWE website http://www.dwe.nsw.gov.au/water/plans_flows_rivers.shtml

In addition to the Cap on extractions in the Murray-Darling Basin, New South Wales has embarked on a process of allocating water to the environment. The economic and social development of NSW relies on the assured water supplies that are provided by water storages. It is therefore not possible to return our rivers to their natural condition. However, in New South Wales, statutory water sharing plans have

been prepared for most of the major river systems that set out rules for sharing water between water users and the environment (Water Management Act 2000). The environmental rules in the water sharing plans are designed to:

- limit extractions so that the major share of water is protected – between 56% and 80% of the average annual water in the regulated river systems will be retained in the river – amounting to over 5 million megalitres in the inland systems.
- replicate natural flow patterns or events so as to provide water when and where it will best meet environmental needs - on average the rules for the regulated rivers will return an additional 220,000 megalitres of water to the environment over and above that required under the Murray Darling Basin Cap.

The environmental flow rules in these plans are based on the following broad river flow objectives (Table 1, next page) that set out twelve aspects of flow considered to be critical for the protection or restoration of river health, ecology and biodiversity.

These River Flow Objectives were subject to extensive public consultation and endorsed by the NSW government in 1999. Their purpose is to produce specific environmental benefits such as:

- improved survival of ecosystems and aquatic biodiversity;
- improved water quality;
- healthier wetlands;
- improved habitat quality and increased variability of habitat for native fish, frogs, waterbirds and other native fauna, including invertebrates;
- more successful breeding of native birds, fish and other native fauna, which only breed in response to specific environmental triggers, for example, rising or falling water levels in the natural seasons;
- more natural inundation of floodplains and wetlands, leading to better health and productivity (such as grazing), protection of endangered species, biodiversity and water quality;
- discouragement of alien pest species, such as carp, which favour regulated conditions;
- improved health of in-stream and riparian vegetation, leading to greater bank stability, improved efficiency of buffer strips in protecting water quality, and reduced erosion and turbidity; and
- reduced frequency of algal blooms.

Table 1: River Flow Objectives

From DWE website: http://www.dwe.nsw.gov.au/water/plans_flows_rivers.shtml

RIVER FLOW OBJECTIVES

Objective 1	protect natural water levels in pools of creeks and rivers and wetlands during periods of no flow
Objective 2	protect natural low flows
Objective 3	protect or restore a proportion of moderate flows, "freshes" and high flows
Objective 4	maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems
Objective 5	mimic the natural frequency, duration and seasonal nature of drying periods in naturally temporary waterways
Objective 6	maintain or mimic natural flow variability in all rivers
Objective 7	maintain rates of rise and fall of river heights within natural bounds
Objective 8	maintain groundwaters within natural levels, and variability, critical to surface flows or ecosystems
Objective 9	minimise the impact of in-stream structures
Objective 10	minimise downstream water quality impacts of storage releases
Objective 11	ensure river flow management provides for contingencies
Objective 12	maintain or rehabilitate estuarine processes and habitats

Between 1967, when Jindabyne Dam was closed, and 2002, flow through the Jindabyne Gorge was reduced so much that annual mean was equivalent to just 4% of the original annual mean at Dalgety (Erskine *et al.* 1999), comprising 1.2% at Jindabyne and the rest from tributary inputs. As described in the original Expert Panel Assessment (Pendlebury *et al.* 1996), the international literature (eg Erskine *et al.* 1999), and documented in various reports from the Flow Response Monitoring program (eg Brooks *et al.* 2007, Gilligan and White 2008), such reductions in volume, in the seasonality and predictability of flows, and the great increase in the duration of low flows have had major degrading effects on geomorphology, habitat and biota of the Snowy River below Jindabyne. The changes in flow have also given rise to significant changes in water quality (eg Bevitt and Jones 2008).

The challenge in seeking to restore the Snowy River to a less degraded state lies in providing environmental flows. The importance of the natural flow regime as a model for environmental releases is recognised in the SWIOID (2002) which states that "*the arrangements and actions contemplated under this Deed are intended to ensure that water releases will to the extent possible mimic seasonal natural flows under prevailing climatic conditions*". More specifically, the task of restoring the Snowy River means attempting, given the annual volume of water available, to most effectively provide flow regimes that meet the five key flow components (Poff *et al.* 1997, Arthington *et al.* 2006) listed above. Attempting to meet these components will be done as to allow the four principles of Bunn and Arthington (2002) to operate satisfactorily. Effective management of the project of providing environmental flows is very dependent on the ongoing monitoring and assessment of the physical, chemical and biotic condition of the Snowy River below Jindabyne Dam.

2.3. Establishing the Context

The basis for this step comes from an understanding of Snowy River flows before the Snowy Mountain Scheme and since the construction of Jindabyne Dam. This allows the identification and magnitude of the natural flow components that have been changed as a result of Jindabyne Dam. It will also allow the identification of the ecological properties of the river that have been weakened by over 35 years of very low post-dam flows, and which will need to be strengthened by releases of environmental flows in order to return the river to an ecologically sustainable state (Snowy Scientific Committee 2008). The changes in the flow regime will need to be interpreted with regard to the changes in the geomorphic context of the river (viz. Poff *et al*. 2006) as it flows from Jindabyne to Orbost.

The objective of delivering environmental flows down the Snowy River, as set out in Annexure One of the Snowy Water Inquiry Outcomes Implementation Deed (SWIOID (2002), is "*to improve the habitat for a diverse range of plant and animal species through a combination of:*

- *[1] improving the temperature regime of the river water*
- *[2] achieving channel maintenance and flushing flows within rivers*
- *[3] restoring connectivity within rivers for migratory species and their dispersion*
- *[4] improving triggers for fish spawning; and*

- *[5] improving the aesthetics of currently degraded riverine environments.*"

This objective and its sub-objectives are strongly aligned with the objectives and recommendations of the Expert Panel Assessment (Pendlebury *et al.* 1996), researchers (Erskine *et al.* 1999), and with New South Wales' River Flow Objectives (Table 1), so are appropriate for implementing the releases. The recommendations from the Expert Panel included a minimum target for flows immediately downstream of Jindabyne Dam (200 ML d^{-1}), an average daily base flow at the confluence of the Snowy and Mowamba Rivers that approximates the 95th percentile of natural for each month, restoring some of the natural daily flow variability (through decommissioning and weir removal), and an annual flood event in the autumn-spring period to entrain sediment.

2.4 Landmark

Until now, the releases made by Snowy Hydro Ltd followed the requirements of the Water Consultation Liaison Committee (WCLC) with no input from the SSC. The temporal pattern of these releases was based on the Default Monthly Release Volumes, so considered only one characteristic of the flow regime, viz seasonal pattern. The schedule for Default Monthly Volumes, as specified in Section 11.4 of Annexure One of the SWIOID (2002), partitions the Annual Allocation across twelve months according to a formula that mimics the overall 'spring snow melt' signal with a peak in October. Historical data for the releases from Jindabyne Dam are plotted in Appendix 2.

The Snowy Scientific Committee is charged with making recommendations on the release 'for environmental reasons'. Its formation, in May 2008, means that components other than seasonal pattern will now be factored into the release regime from Jindabyne Dam, starting with the coming water year (2009-2010), and that a release regime can be implemented that is tailored to the ecological priorities arising from much lower than expected flows down the Snowy River.

Section 3: Recommendations

3.1. Setting Priorities

In October 2008, the Snowy Scientific Committee submitted its report to the NSW Water Administration Ministerial Corporation entitled "Adequacy of Environmental Releases to the Snowy River" (SSC 2008). This report used information already available through publications from the Snowy River Flow Response Monitoring project, in the peer-reviewed scientific literature, and through submissions to the Snowy Hydro Licence Review. It included statements of the condition of the Snowy River downstream of Jindabyne Dam, and spelled out priorities for environmental releases. These statements about the Snowy River were the first since environmental releases began in 2005 and the first since the Expert Panel report (Pendelbury *et al*. 1996) and Erskine *et al.* (1999), some 9-12 years earlier.

It is very evident that the volumes of water released from Jindabyne Dam have been inadequate for the establishment and ongoing maintenance of natural stream conditions. This is particularly evident in certain aspects of the flow regime: the lack of temporal variability (daily to seasonal), the lack of channel maintenance and channel-forming flows, and the lack of flows to prevent oxygen stratification in deep pools below Jindabyne Dam. These are therefore the priorities for environmental releases for 2009-2010 Water Year (SSC 2008).

The extent to which these priorities can be achieved depends on the size of the Annual Allocation.

3.2. Annual Allocation and SRIF

On 11 February 2009, the NSW Department of Water and Energy advised (Paul Simpson, pers. comm.) that the Annual Allocation to the Snowy River for 2009-2010 would be 42.2 GL. Following the distribution pattern set down in the SWIOID (2002) and summarised in Five Steps in Appendix 1, this means that, *provisionally*, 38 GL is available for release from Jindabyne Dam as Snowy River Increased Flows (SRIF); it also means that, as Annual Allocation exceeds the threshold value of 38 GL, there will be (again, *provisionally*) a 4.2 GL repayment to the Mowamba Borrowings Account (Table 2) for water year 2009-2010.

The estimates of the SRIF and the repayment of the Mowamba Borrowings Account are *provisional* because volumetric adjustments still have to be made for Overs &

Unders[1], and these will not be known until the completion of the 2008-2009 Water Year, ie in late May/early June. However, based on information so far, the necessary adjustment is not expected to be large and likely to be less than 1 GL (Andrew Nolan, Snowy Hydro Limited, pers. comm. 20 March 2009). Both these are considerably less than the 10% tolerance[2] for annual volumes specified in the Snowy Hydro Licence.

The provisional estimates for SRIF for 2009-2010 show that it is similar in volume to all the releases made since 2005-2006, which have all been in the 32-38 GL range. The Snowy Scientific Committee considers SRIF of 38 GL and below to be 'very low'. Consequently, environmental releases can only seek to preserve what is there, analogous to a life support system, and seek to deliver those flow regime characteristics that are important for resilience in biota.

The Snowy Scientific Committee is not alone in having to decide how best, in the long-term interests of the river, to use the small volumes available; this is a decision that is confronting river managers elsewhere in south-eastern Australia. The Living Murray, for example, has set the following priorities for environmental watering: avoid critical loss of threatened species; avoid irretrievable damage or catastrophic events; and provide refuges to allow re-colonisation following drought (MDBC 2008).

Table 2: Annual Allocation and SRIF for 2009-2010

This provisional estimate of SRIF for 2009-2010, derived from the Annual Allocation as set out in the SWIOID (2002). TBA means To be Advised, in late May or early June. Provided by Paul Simpson, DWE, pers. comm..

	Debits/Credits		SRIF
Annual Allocation (GL)	Mowamba Borrow (GL)	Overs & Unders (GL)	Volume for Release (GL)
42.2	4.2	TBA	38

The total volume to be considered when making release recommendations is slightly greater than the SRIF, as it is the sum of Snowy River Increased Flows plus Base

[1] **Overs & Unders**: Term used to refer to shortfall or excess releases, as specified under Provisions 5.1(2) of the Snowy Water Licence 2002.

[2] **10% tolerance on annual volumes:** specified in Schedule 3, Paragraph 12.1 of the Snowy Water Licence, as issued on 30 May 2002.

Passing Flow (BPF). Using the provisional estimates of SRIF = 38 GL, and Base Passing Flows of 9 GL (which is fixed) as set down in the SWIOID (2002), this gives a total of 47 GL (SRIF + BPF which is 38 + 9). Note that the actual total will not be finalised until late May / early June 2009 when the Unders & Overs is known.

The following recommendations presume that the SRIF will be 38 GL or very close to 38 GL. Adjustments larger than 1 GL could trigger an amended set of recommendations. This is because, under the very low volumes for SRIF, a +/- change of 1 GL could modify the expected ecological effectiveness of a particular flow component.

3.3 Flow Recommendations for 2009-2010

Based on the provisional estimates of SRIF for 2009-2010, the Snowy Scientific Committee makes two flow recommendations.

Recommendation 1: Provide a persistent but variable base flow throughout the year; this should average about 90 ML d^{-1} for nine months of the year, but for the three mid-winter months it should average about 160 ML d^{-1} for the first month, 290 ML d^{-1} for the second month and then 160 ML d^{-1} for the third month.

Aim: To maintain aquatic habitat and wetted perimeter of the channel.

Rationale: In times of environmental stress, it is essential to maintain habitat in as best a condition as possible. Flow is only one of several influences on in-stream habitat quality but it is a major one that defines extent and character, and determines processes so it is important to use environmental flows to best possible effect. The year-round delivery of a baseflow is expected to ensure the presence of pool and riffle habitats throughout the year: this is essential for obligate aquatic species. Providing short-term variability in discharge is expected to provide hydraulic variability: velocity changes are important for productivity and for maintaining habitat character; and depth and water level changes are important for maintaining a wet-dry littoral zone. Providing a higher baseflow from mid-June to mid-September is expected to break the extended run of low baseflow and to protect the river from extreme low temperatures, as well as immerse more habitat and increase both primary and secondary productivity. This seasonal peak is intended to begin re-introducing annual seasonal base flow variability. The annual spring snowmelt signal of peak flows in September-October is not possible with the SRIF volumes available.

Note: The low SRIF available for environmental release in 2009-2010 means that the hydraulic variability that can be achieved is small relative to what the river ecology needs, and will be attenuated downstream.

Details – Discharge Variability: From mid-September to mid-June, discharge should average 90 ML d^{-1} but should vary on a weekly basis from 80 to 100 ML d^{-1}; from mid-June to mid-July, discharge should average 160 ML d^{-1} but should vary on a weekly basis from 150 to 180 ML d^{-1}; from mid-July to mid-August, discharge should average 290 ML d^{-1} but vary on a weekly basis from 260 to 320 ML d^{-1}; and from mid-August to mid-September, discharge should average 160 ML d^{-1} but should vary on a weekly basis from 150 to 180 ML d^{-1}.

Recommendation 2: A peak flow of 870 ML d^{-1}, lasting 1-2 days, should be released in January; and again in February.

Aim: To minimise the likelihood of poor water quality in pools and consequent stress on in-stream fauna.

Rationale: Under low flow conditions and particularly during summer months, there is a risk that pools in the upper reaches, particularly in Jindabyne Gorge, will stratify, resulting in high temperatures in the epilimnion and low to very low oxygen levels in the hypolimnion. These peak flows are intended to break down and temporarily arrest the development of stratification in the pools.

Note: The low volume available for environmental release in 2009-2010 constrains what can be achieved, hence this recommendation is a trade-off between the magnitude of the release, the number of releases that can be achieved, and the duration of each. These peak flows are not expected to have a permanent mixing effect on the pools, and stratification is likely to start re-developing some time after the flow event. The expected outcome from a peak flow in summer is to reduce the time that pools are stratified and to reduce the strength of the stratification when it does re-establish. The mixing effect would last longer if peak flows were higher than 870 ML d^{-1}, or lasted longer than 2 days, or occurred more frequently than twice in the summer period.

Details - Timing: Ideally, each of these releases should be triggered by a catchment rain or summer thunderstorm event, with releases commencing within 24 hours of a natural event. The reference points suggested for identifying triggers are Thredbo River at Paddy's Corner or the Mowamba River upstream of the Aqueduct and Weir

(such as gauging station 222027 Mowamba River @ Lynwood where water levels are logged continuously). If there has been no such trigger in the first three weeks of January (or February) then the default is for a release to be made in the last week of the month.

If the ideal is not feasible, then the default applies: ie the release should be made in the last week of each month.

Details – Hydrograph Shape: The rising limb should be: from baseflow to 400 ML d^{-1} over 6 hours, from 400 ML to 870 ML d^{-1} in next 6 hours. Peak discharge: hold at 870 ML d^{-1} for 36 hours. Falling limb: from 870 ML d^{-1} to baseflow in 12 hours.

3.4. Flow-Temperature Recommendation

The Snowy Scientific Committee makes one flow-related recommendation in relation to temperature.

Recommendation 3: Water from Jindabyne Dam should be released so as to minimise the combined negative effects of river regulation and diversion on downstream water quality including river temperatures.

Aim: To capitalise on the opportunity offered by the multi-level off-take that has been retro-fitted to Jindabyne Dam by selectively delivering, insofar as is feasible, water that is both epilimnetic and that can help mitigate the modified river water temperatures recorded for the Snowy River in Jindabyne Gorge.

Rationale: River regulation, ie the presence of a large impoundment and the diversion of large volumes away from the river, and the release of hypolimnetic water can change in-stream water quality. The issue of altered thermal regime and poor water quality was recognised (*inter alia*) as an issue for the Snowy River downstream of Jindabyne Dam, hence: *improving the temperature regime of river water* was one of the five environmental objectives specified in the outcomes deed (SWIOID 2002); seasonal improvements in temperature were included as testable hypotheses in the water quality monitoring program (Bevitt and Jones 2008); and the capacity to release water from the epilimnion via a moveable off-take has been retro-fitted to Jindabyne Dam.

In regulated rivers, there is an intricate relationship between flow (ie release volumes) and downstream water temperatures. Such a relationship has been empirically established for the Snowy River for the period 1997 to 2002, and for the

flow conditions of that period ie Jindabyne syphon, between releases from Jindabyne Dam and mean, maximum and minimum temperatures at Dalgety (Bevitt and Jones 2008).

Details: The record of *actual* temperatures of the Snowy River from Jindabyne Gorge to Dalgety, the temperatures that *need to be released* to mitigate the effects of the Dam, and the temperature of water that *can be released* into the Snowy River from above the thermocline, all show strong seasonal patterns (Bevitt and Jones 2008, Appendix 3). Because of this strong seasonal signal, it may be possible for the Snowy Scientific Committee to develop some rules of thumb or guiding principles for releases from Jindabyne Dam, for the following Water Year (ie 2010-2011).

3.5 Expectations

Informed feedback is essential for improving river management, and for early detection of critical ecological issues.

The Snowy Scientific Committee expects that DWE will ensure its on-going and continued support for the Flow Response Monitoring program; and that the Flow Response Monitoring team will continue to summarise their findings frequently and report on them regularly.

A copy of this report (dated April 2009) with its Release Recommendations based on the *provisional* estimates of volumes available was forwarded to DWE and WCLC on 30th April 2009.

Section 4: Finalisation

4.1 Finalising the Release Volumes

Finalisation of volumes and hence of Release Recommendations was done in two stages.

The first was on 18th May 2009, when DWE advised the Snowy Scientific Committee that the 'Overs and Unders' correction to be applied to environmental flows to be released from Jindabyne Dam was -0.3 GL. Thus the actual volume for SRIF for 2009-2010 is 37.7 GL (38 GL less -0.3GL).

Table 3: Finalisation of SRIF for 2009-2010

This is the corrected estimate of SRIF for 2009-2010, derived from the Annual Allocation as set out in the SWIOID (2002). Based on data provided by Paul Simpson, DWE, pers. comm.

	Debits/Credits		SRIF
Annual Allocation (GL)	Mowamba Borrow (GL)	Overs & Unders (GL)	Volume for Release (GL)
42.2	4.2	- 0.3	37.7

At the same time, DWE also advised that 0.5 GL of the 9 GL Base Passing Flow is released down the Mowamba River, and hence only 8.5 GL of BPF is released from Jindabyne Dam. Hence the volume to be released from Jindabyne Dam is actually 46.2 GL (37.7 SRIF + 8.5 BPF).

The second was on 30th May, when DWE advised the Snowy Scientific Committee of an error made by DWE when operationalising the SSC Release Recommendations. This error was in the distribution of volumes through the year and had no effect on the release volume.

4.2 Finalising the Recommendations

First adjustment: In relation to the first adjustment, the Snowy Scientific Committee accommodated this downward correction of 0.8 GL to the release volume by modifying Recommendation 1, ie targeting the overall seasonal pattern and reducing it slightly and suggesting that flows in the winter months from mid-June to mid-

September would need to be lower by 10 ML d^{-1}. The revised Recommendation 1 reads:

- from mid-June to mid-July, discharge should vary on a weekly basis from 140 to 170 ML d^{-1};
- from mid-July to mid-August, discharge should vary on a weekly basis from 250 to 310 ML d^{-1};
- from mid-August to mid-September, discharge should vary on a weekly basis from 140 to 170 ML d^{-1}.

A revised version of the Release Recommendations report, with these recommendations and dated May 2009, was submitted and posted on the web on 29th May 2009.

Second adjustment: In relation to the second adjustment, the Snowy Scientific Committee decided to re-instate, for as many days as possible, the higher flows in winter in order to achieve as much seasonal variation as possible. Thus Recommendation 1, after this second adjustment, now reads:

- from mid-June to mid-July, discharge should vary on a weekly basis from 140 to 170 ML d^{-1} but increasing to 150 to 180 ML d^{-1} as a weekly variation if practicable;
- from mid-July to mid-August, discharge should vary on a weekly basis from 260 to 320 ML d^{-1};
- from mid-August to mid-September, discharge should vary on a weekly basis from 150 to 180 ML d^{-1}.

Recommendation 2 regarding the two summer peaks remains unchanged. Advice from DWE and SHL is that the two summer peaks (brief, only 3 days) are scheduled to occur at the beginning of the last week of January and the beginning of the last week of February, respectively.

A revised version of the Release Recommendations report, with these two recommendations and dated June 2009, was submitted and posted on the web on 5th June 2009.

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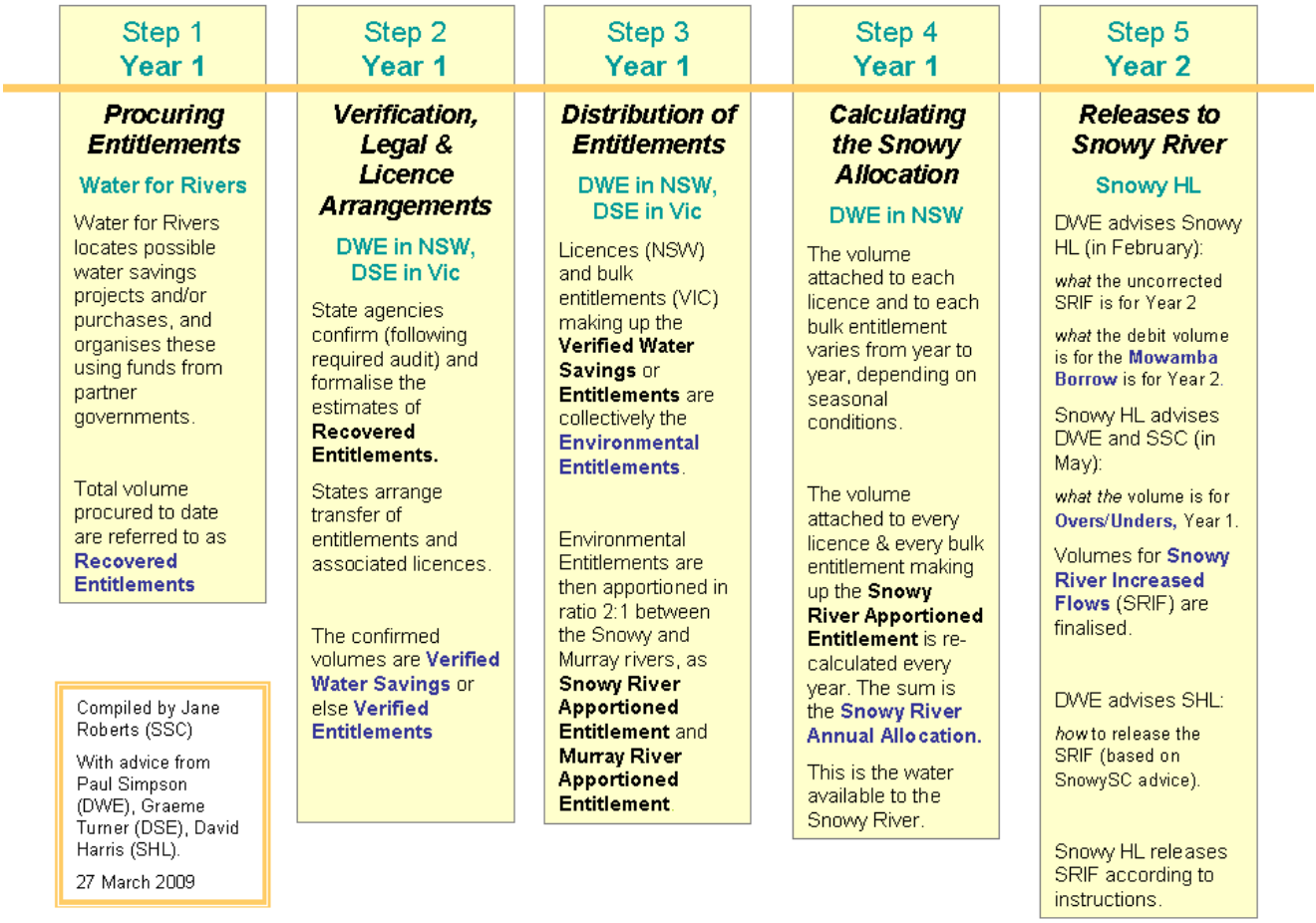
Appendix 1: Five Steps

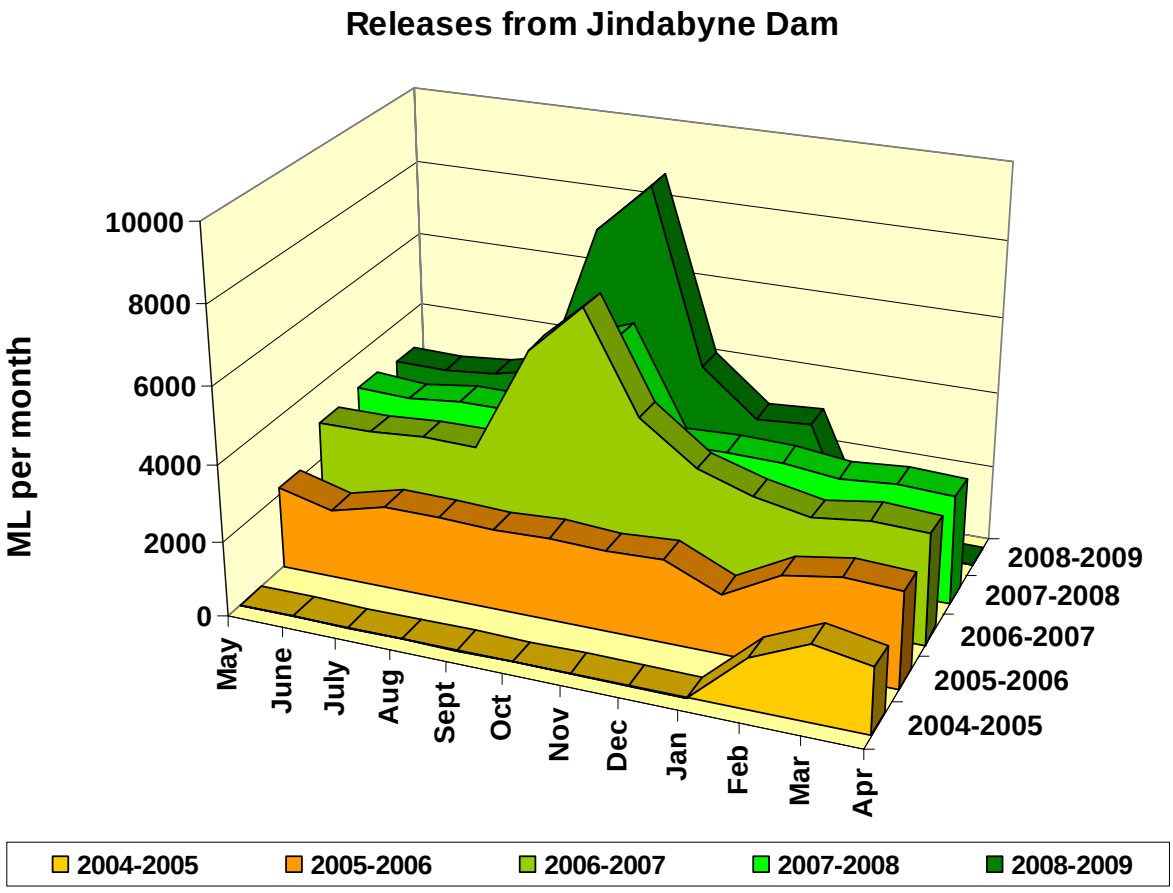
A summary of the process from procuring entitlements to determining the volume for release from Jindabyne Dam, and showing the different organisations involved.



Appendix 2: Jindabyne Dam Releases

A time series of monthly releases from Jindabyne Dam, being the sum of Snowy River Increased Flows and Base Passing Flow, is shown below from the time of the first releases in February 2005 to January 2009 inclusive. The record is complete for only three Water Years so far. These releases are referred to the SHL gauging station "Snowy River @ Cobbin Creek". Note that from Feb 2005 to Sept 2006 inclusive, the data in fact refer to the siphon at Jindabyne Dam so are estimated releases, based on engineering rating, rather than direct measurements. Releases have been recorded daily since 2 September 2006.

Note that the Jindabyne releases for 2005-2006 are not the entire volume of SRIF as part of SRIF for this water year was through the Mowamba River.



Appendix 3: Lake Jindabyne Temperature Profiles

Periodic temperature profiles for a standard site near the dam wall from March 2006 to March 2008 (n=25) show a strong seasonal pattern (provided by Andrew Nolan, Water Resources, Snowy Hydro Ltd.). Combining all 25 profiles, the following trend emerges:

General surface and upper layers warming through spring (October-November) that results in a well-developed thermocline in mid-summer (December-January); the thermocline present until early autumn (usually March) then it begins to break down, becoming virtually isothermal for the cooler months of late autumn-winter (April-May through to September). The coldest thermal profile recorded to date was 7.3-7.6 deg C, in July 2007. Thus the temperature of the top 5 metres may range over 15-16 deg C, from 7 to 22-23 deg C.

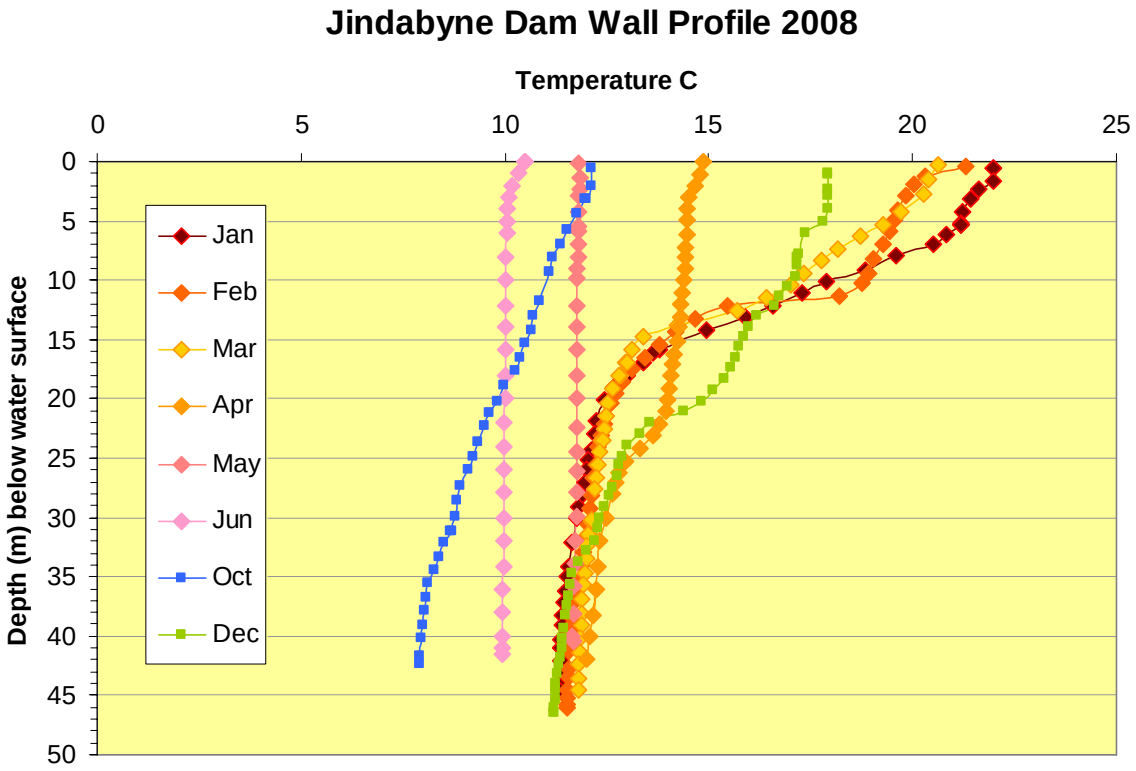


Figure A3.a: Temperature profiles for eight dates in 2008