

# **Data versus Desktop: An assessment of the severity of Cold Water Pollution in the Swampy Plains and Murray Rivers below Khancoban Dam**

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## **Key Points**

- Cold Water Pollution occurs downstream of Khancoban Dam but effects are not as severe or persistent as expected on the basis of the original desktop study
- Summer suppression is evident but winter elevation, annual amplitude reduction, seasonal displacement and impacts to diel variation are very minor
- Causes of cold water releases appear to be a combination of reservoir stratification and releases from Murray 2 Power station with releases from the power station being the dominant cause
- The presence of Khancoban Reservoir appears to be having a minor impact on the percentage of time that breeding temperature thresholds are exceeded during the breeding seasons of a number of native fish expected to occur in the Swampy Plains and Murray Rivers.

## **Abstract**

In 2004, Khancoban Dam was listed as one of 9 Dams in NSW considered to cause severe cold water pollution on the basis of a desktop study. This study, based on 5 years of field data, demonstrates that cold water releases do occur from Khancoban but that these events are not as severe or prolonged as expected. On average, there is a difference in temperature of only -2.2°C between monitoring points upstream and downstream of Khancoban Dam during summer.

Investigations into the cause of cold water releases from Khancoban Dam have found that these releases can occur both as a result of high releases from Murray 2 power station (M2) and as a result of reservoir stratification during periods of low generation at M2, although releases from the power station are the dominant cause. When high releases are occurring from the power station, the reservoir is isothermal meaning that modifying the dam intake to selectively withdraw water from different levels would have no impact on the temperature of releases during these periods.

In terms of ecological implications, the presence of Khancoban Reservoir appears to be having a minor impact on the percentage of time that breeding temperature thresholds are exceeded during the breeding seasons of a number of native fish expected to occur in the area.

## **Keywords**

Cold water pollution, Khancoban reservoir, Upper Murray River

## **Introduction**

Water temperature is a fundamental ecological variable in a river system that directly influences aquatic species. It also determines rates of ecological processes including nutrient cycling and productivity (Cassie, 2006; Olden & Naiman, 2010). Thermal cues derived from the natural temperature of a river are vital for stimulating fish migration, spawning and egg hatching and has been shown to directly influence egg

survivorship and developmental time. There is evidence that suggests reservoir-induced thermal alteration has significant implications for in stream ecology (Olden & Naiman, 2010; Astles, et al., 2003).

The purpose of this study was to assess the potential impact of the presence of Khancoban Reservoir, on the water temperature of the Swampy Plains and Murray Rivers above Hume Reservoir. The basis for any original concerns raised about the impact of this reservoir has been investigated and the results of data collected presented. Comparisons have also been made to results from other ‘high priority’ reservoirs within the State. In addition, a discussion on the potential ecological impacts of these findings has been presented.

In 2004, the NSW Department of Land and Water Conservation and NSW Fisheries initiated a desktop study to identify which dams in NSW had the greatest potential to cause cold water pollution (CWP). From a shortlist of 93 dams, the study identified nine dams that were considered to be causing large and pervasive CWP (Table 1)(Preece, 2004). One of these was Khancoban Dam, located on the Swampy Plains River near Khancoban Township. It is a small earthfill dam that impounds the water discharged from M2 Power station, part of the Snowy Mountain Scheme, for release to the Swampy Plains River at a uniform rate of flow (SHL, 2003). The characteristics of the dam and those of the other ‘high priority’ dams identified by Preece (2004) are presented in Table 1.

**Table 1. Structures considered likely to cause severe cold water pollution (Preece, 2004, p. 12)**

Rank	Name	Owner <sup>a</sup>	Height (m)	Surface Area (km <sup>2</sup> )	Capacity (ML)	Mean Depth <sup>b</sup> (m)	Intake Depth (m)	Discharge (ML day <sup>-1</sup> )
1	Blowering	SW	112	44.6	1 628 000	36.5	74	8 200
2	Hume	MDBC	51	202.0	3 038 000	15.0	29	20 000
3	Copeton	SW	113	42.6	1 364 000	32.0	69	3 600
4	Burrinjuck	SW	93	55.0	1 026 000	18.7	42	5 200
5	Burrendong	SW	76	72.0	1 190 000	16.5	37	4 000
6	Wyangala	SW	85	53.0	1 220 000	23.0	50	1 700
7	Keepit	SW	55	44.0	423 000	9.6	24	2 000
7	Khancoban	SH	18	4.7	21 500	4.6	12	4 000
9	Pindari	SW	85	10.5	312 000	29.7	11	1 000

a. SW = State Water; MDBC=Murray Darling Basin Commission; SH = Snowy Hydro Ltd.  
 b. Storage capacity divided by surface area at FSL

This study has compared temperatures measured for Khancoban Dam releases and compared these with temperatures observed in the Swampy Plains River above this reservoir. The study included two main aims:

- Determine whether cold water releases occur from Khancoban Dam and if so, assess the frequency and severity; and
- If occurring, investigate the reasons for cases of CWP emanating from the dam

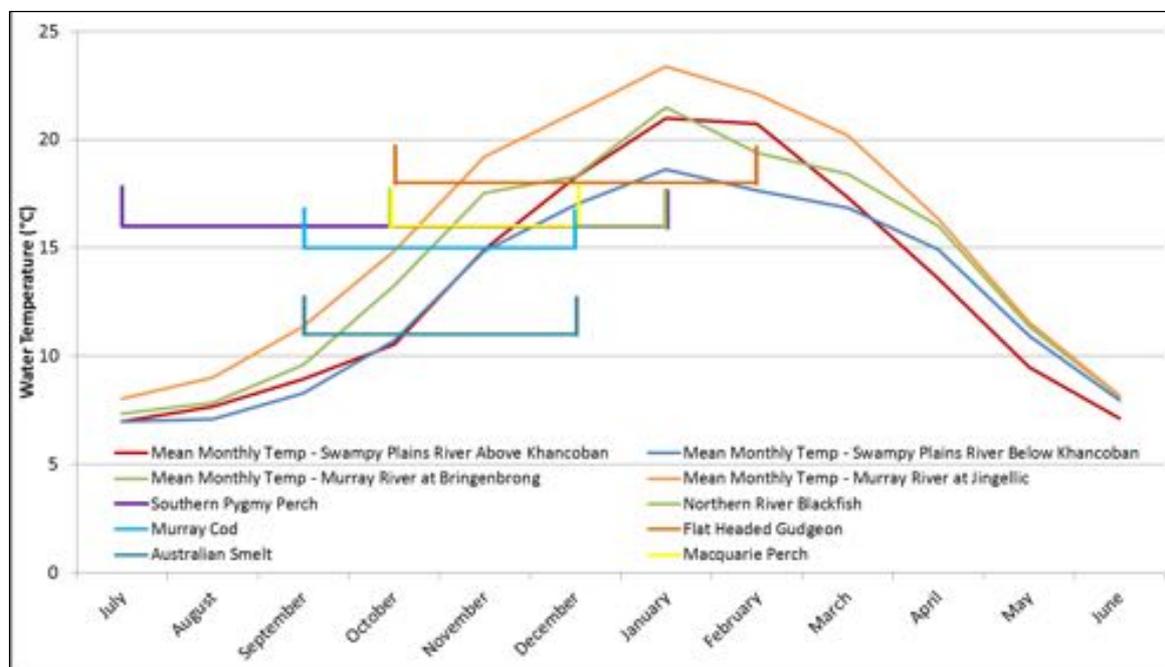
## Study Area and Method

TidbiT v2 Hobo Data Loggers from Onset (UTBI-001) were co-located with existing hydrometric gauges upstream and downstream of the Dam at a distance of about 10km from each other. Loggers were also installed at the boom within the M2 power station tailbay and at the NSW Dol Water Hydrometric gauge on the Murray River at Brigenbrong Bridge (401549), approximately 14 km downstream of Khancoban Dam. Water temperature data for the Murray River at Jingellic (401201), located approximately 85 km downstream of the dam, were sourced from the Victorian Water Measurement Information System. To obtain thermal profiles within Khancoban Reservoir, a weighted string of TidbiTs attached at 1m intervals was fastened to the existing log boom near the dam wall. Data were collected during two periods, between 21/07/00 and 21/06/02 and between 29/07/11 and 31/03/15 for a total of 1,898 days. Data were only included when information was available both upstream and downstream of the reservoir. For the statistical modelling, days were only included when data for multiple variables were available. Due to failures of the monitoring equipment, some gaps exist in the data.

## Results and Discussion

Differences in the water temperature of releases from Khancoban Dam compared to upstream are minor in all seasons. Average differences in mean monthly water temperature between upstream and downstream are largest in January and February with a difference of 3°C (Figure 1). The annual average minimum monthly temperature of 7°C occurs in July at both locations which suggests that winter elevation and seasonal displacement is not apparent downstream of the Dam (Figure 1). The maximum mean monthly temperature occurs in January at both locations (Figure 1). A very minor delay to warming is evident below the dam in August and September however the difference is less than 1°C. Temperatures below the dam are also slightly warmer than upstream in April, May and June which suggests that the dam has a minor buffering effect in autumn and early winter although impacts are again of a very small magnitude (Figure 1). Data for the River Murray at Jingellic shows that the water continues to warm after it leaves Khancoban and mixes with other tributary inflows. In all months the temperature of the River Murray at Jingellic is warmer than that of the Swampy Plains River both above and below Khancoban Reservoir. The average January temperature is 5°C warmer at Jingellic compared to immediately below Khancoban Dam (Figure 1).

Figure 1 also shows the spawning envelopes for the species considered to be ‘Common’ or ‘Abundant’ in pre-European times in the Upper Murray River by Gilligan et al. (2010) where their spawning thresholds are triggered more than 10 per cent of the time in the Swampy Plains River above Khancoban. Of these species, only the flat headed gudgeon, which has the highest spawning threshold, is affected by the colder summer temperatures experienced below Khancoban reservoir (Figure 1). It is also evident that longitudinal temperature increases in the River Murray downstream of Khancoban Reservoir are sufficient to enable the spawning envelopes of all key species to be exceeded at the River Murray at Bringenbrong and Jingellic, i.e. only 14km from Khancoban Dam (Figure 1).



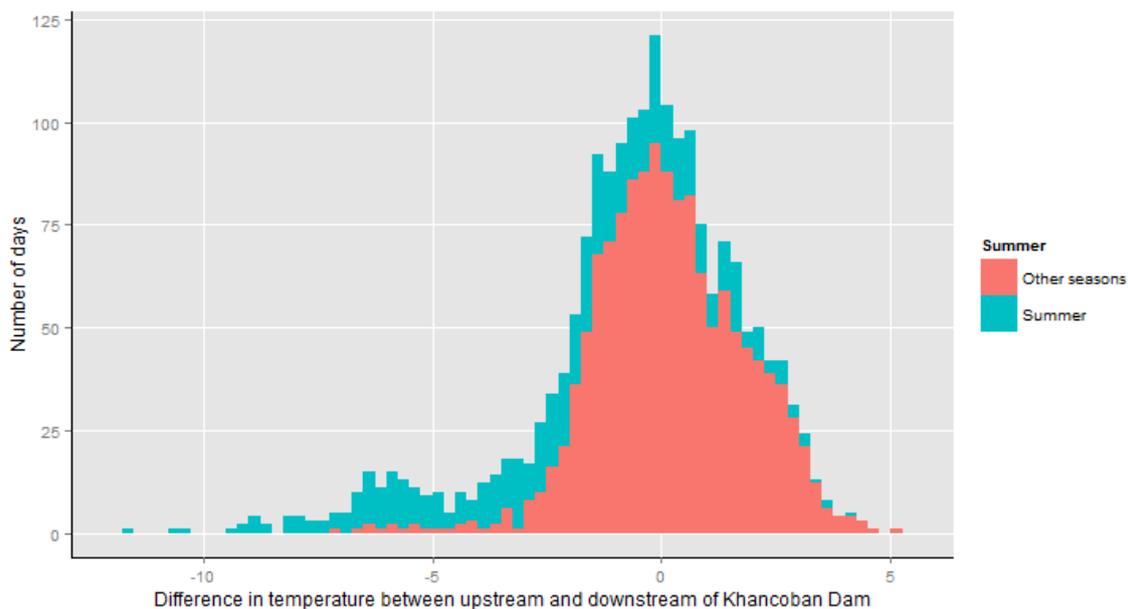
Note: The period of record for the Bringenbrong data is shorter and runs from June 2013-March 2015. Temperature thresholds and spawning periods sourced from (Lugg, 1999) and (Lintermans, 2009).

**Figure 1. Long Term Average Monthly Temperatures observed in the Swampy Plains River above and below Khancoban Dam and in the River Murray at Jingellic. Spawning envelopes for selected fish species are also included.**

The data presented for Khancoban is in contrast to other data available for another ‘high priority’ dam. A study by DPI showed that water in the Murrumbidgee River below Burrinjuck and Blowering Dams remains below the required thresholds for fish spawning of key species expected to occur in the Murrumbidgee River, even 240 km downstream from Burrinjuck dam (DPI, 2013). The greater magnitude of temperature suppression observed below Burrinjuck and Blowering Dams compared to Khancoban is most likely to be due to the much greater storage capacity and depth of these reservoirs (Table 1) which would make them much less susceptible to short term changes in water temperature based on inflows and weather events.

The annual maximum mean daily water temperature recorded each summer below Khancoban was 1.7°C lower in all years compared to the temperatures recorded upstream. The timing of the annual maximum was shifted by 0-2 months from that recorded upstream with an average delay of less than one month. These results are much less than differences observed below Burrendong Dam on the Macquarie River. According to Olden and Naiman (2010), prior to the recent modifications, the annual maximum temperature downstream of Burrendong was reduced by 8-12°C and the maximum temperature occurred 1-3 months later than the ‘natural’ maximum.

According to Preece (2004), the water temperature below the nine high priority dams (which include Khancoban) (Table 1) could be more than 10°C lower than natural. The mean daily temperature of releases from Khancoban was more than 10°C colder than the mean daily upstream temperature on only 3 days in this study (Figure 9). On a daily time-scale, the impact of the Dam on water temperature is less than that expected for a ‘high priority reservoir’. Ninety four per cent of the time releases downstream of Khancoban Dam are within ±5°C of upstream temperatures (Figure 2). In terms of severity, the reduction in daily downstream temperatures is relatively minor with an average 0.5°C reduction over the full period of record and 2.2°C during summer.



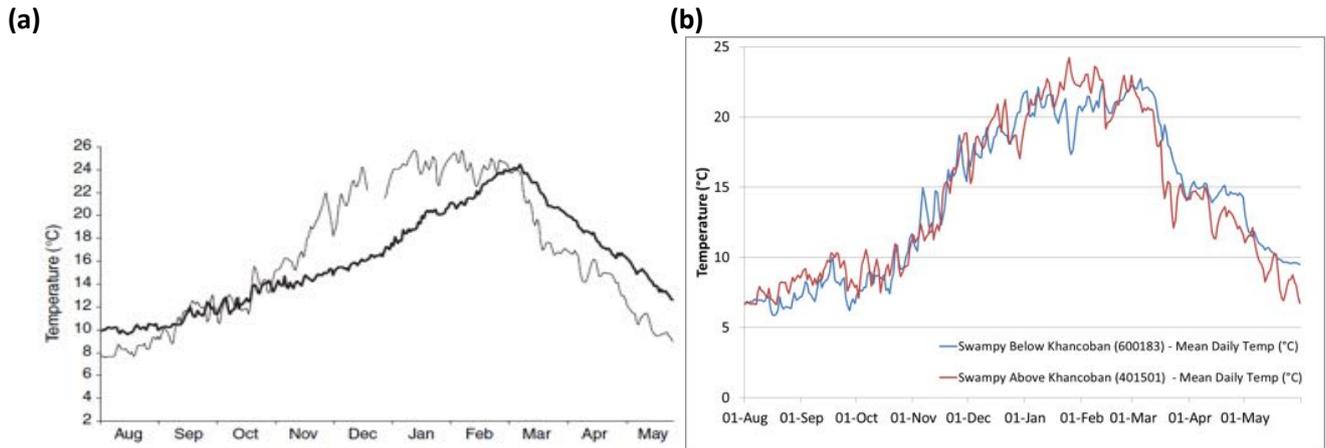
**Figure 2. Histogram prepared by Cardno showing the distribution of the difference between the daily average water temperature of the Swampy Plain River below and above the Khancoban Dam for the summer season and the other three seasons combined.**

When compared to other high priority reservoirs, the scale of cold water releases from Khancoban Dam is significantly less. Figure 3 shows that Hume Dam, which is located further downstream on the Murray River, persistently reduces the downstream water temperature by 6 - 7°C throughout the summer months whereas the effect downstream of Khancoban Dam during the same period is negligible (Figure 3).

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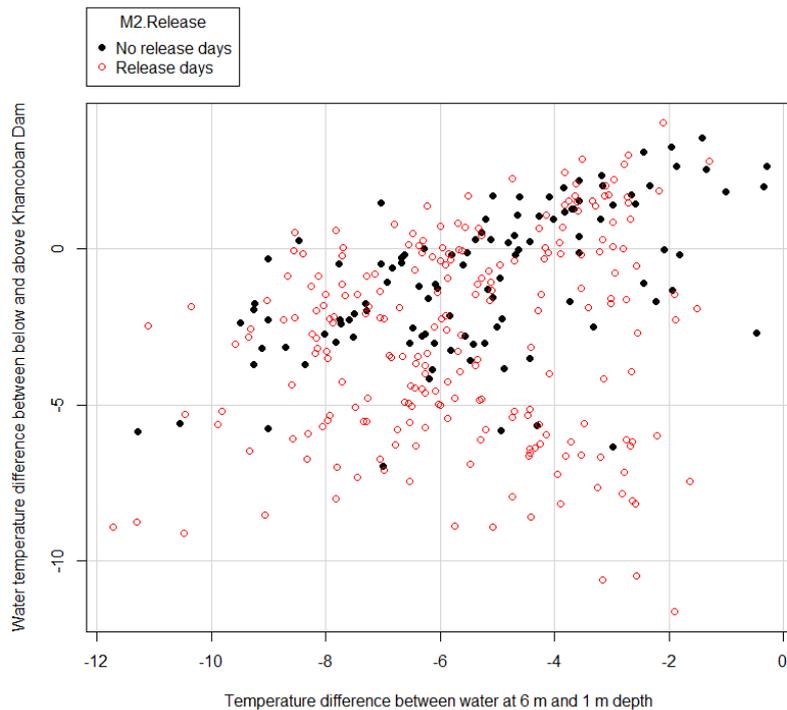
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Despite stratification occurring within Khancoban Reservoir in summer, this does not always translate to cold water releases. There is no evidence of a strong relationship between cold water releases and stratification during summer ( $r^2 = 0.08$ ,  $p < 0.001$ ). When the data are separated into days when high releases from M2 occurred and days when they didn't, stratification is weakly correlated with cold water releases only on days when no releases occurred from M2 ( $r^2 = 0.33$ ,  $p < 0.001$ ) (Figure 4). Based on all days in this study, zero release days from M2 occur less than 20 percent of the time. Importantly, of the 120 days when releases from Khancoban were more than 5°C colder than upstream, only 12 of these events (i.e. only 10%) occurred when there were no releases from M2. This suggests that the operation of the power station has a bigger influence on the frequency and severity of cold water releases than reservoir stratification.



*Black line represents temperatures collected upstream of Hume Dam (Jingellic) and bold line represents temperatures collected downstream*

**Figure 3. Comparison of average daily temperatures (a) above and below Lake Hume (Lyon, et al., 2007, p. 185) and (b) above and below Khancoban Pondage during the 2000/01 irrigation period.**



**Figure 4: Scatterplot of temperature difference at 6 m and 1 m depth versus temperature difference below and above Khancoban Dam for days in which M2 release did not occur and days when it occurred.**

## **Conclusions**

The results presented in this study have shown that the original classification of Khancoban Reservoir as 'high priority' in the study by Preece (2004) is not justified. The effect of Khancoban Reservoir on downstream water temperatures is significantly less than that of other 'high priority' reservoirs identified in the study and 'severe and pervasive' cold water pollution does not occur downstream of Khancoban Dam.

The results suggest that installing infrastructure at Khancoban Dam that allows for water to be selectively withdrawn from near the surface of the reservoir is not warranted. Although cold water releases do occur from Khancoban, the frequency and severity of these releases are considerably less than those observed at other 'high priority' reservoirs. In addition, due to the fact that many of the instances of cold water releases are caused by high releases from M2 power station as opposed to reservoir stratification, releases of unseasonably cold water can occur from Khancoban when the reservoir is isothermal, a situation where the existence of additional infrastructure such as a multi-level intake or curtain would not have any effect.

## **Acknowledgments**

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