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Report to the Murray-Darling Basin Commission

Robyn J. Watts, Darren S. Ryder, Adrienne Burns, Andrea L. Wilson, Errol Nye, Alek Zander and Remy Dehaan

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Executive Summary

Project objective and study design

- The objective of this project was to examine the responses of biofilm biomass and algal diversity to cyclic flow releases in the Mitta Mitta River during a low discharge period from Dartmouth Dam.
- Two sites in the Mitta Mitta River, one reference site in the unregulated tributary Snowy Creek and a control site in the Buffalo River were sampled during this study from 6th April to 4th May 2006. During the study period two low-discharge weekly cycles (approx 200-400 ML/d averaging 300 ML/d over a week at Colemans gauge) were released from Dartmouth Dam, followed by two higher-discharge weekly cycles (approx 300-900 ML/d averaging 400 ML/d over a week at Colemans gauge). The cyclic flows resulted in only a slight increase in inundation of the cobble bars in the Mitta Mitta River.
- Water quality indicators measured at each site were total suspended solids, temperature, conductivity, dissolved oxygen, pH and turbidity.
- Biofilms were used to assess the ecological response to flow change. Biofilms are a combination of bacteria, algae, fungi and detritus that grow on submerged surfaces. Biofilms are central to important nutrient and biogeochemical processes and are a major food resource for higher organisms including crustaceans, insects and some fish. They are excellent indicators because they respond more rapidly to flow changes than higher organisms.
- The total biomass (dry weight of biofilm on cobbles measured in g/m^2), organic biomass (the total biomass minus the inorganic component measured in g/m^2) and algal biomass (Chlorophyll-a measured in mg/m^2) and biofilm species composition were assessed from cobbles collected on each sample date. Additionally, the total, organic, and algal biomass were assessed from artificial substrates that were deployed at each site at the beginning of the study period (6/4/06) and the beginning of the 300-900ML/day cycles (20/4/06).
- There are two aspects of the design of this study that need to be considered when interpreting the results. Firstly, the short duration and timing of the study (4 weeks in Autumn) means that we can provide only a snapshot of biofilm response within a much longer period of cyclic flows. Secondly, the consecutive nature of the two smaller weekly cycles followed by two larger weekly cycles limits the ability to determine if there are independent responses of biofilms on cobbles to each of the different cycles. To overcome this limitation we used an experimental approach of deploying artificial substrates at each site at the beginning of the study (6/4/06) and the beginning of the 300-900ML/day cycles (20/4/06). The differences in newly established biofilms will be compared between the two 14 day periods, removing the influence of antecedent conditions on biofilm formation.

Results

- The hypothesis that TSS would be higher during the 900ML/day peak discharge compared to the 400ML/day peak discharge was not supported. After several months of cyclic flows there may have been little sediment available to be re-suspended during the later cycles.
- Total and organic biomass of permanently inundated biofilms on cobble increased throughout the 4 week study period. Thus the hypothesis that total biofilm biomass on cobbles would decrease during the peak of the 900ML/day CRP peak due to scouring of biofilms from increased velocity was not supported. This suggests there was no major flow-related loss of total biofilm biomass in response to the higher velocity flows of the CRPs. In contrast, algal biomass on cobbles did decrease at the upstream site (site 1) in the Mitta Mitta River during the last 2.5 weeks of the study. It is possible to observe a reduction in algal biomass with no concurrent decrease in total biomass. Algal biomass can respond independently of total biomass because total biomass is driven by silt and the non-chlorophyll algal components of biofilms. Since algal biomass is measured in mg/m^2 and total biomass is measured in g/m^2, a significant change in algal biomass between samples may not be detectable in total biomass.
- There was an increase in total biomass on the artificial substrates over the 28 day study period at all sites. There was no difference in the total biomass on artificial substrates in the Mitta Mitta River after 14 days of 300-900ML/d cycle compared to the 14 days of 200-400ML/d cycle. This is consistent with the observed increase in total biomass on the cobbles and suggests there was no loss of total biomass in response to the higher velocity flows of the CRPs. However, the algal biomass on artificial substrates at the upper Mitta Mitta site after 14 days of the 300-900 ML/d cycles was significantly less that the biomass established during the 14 days of 200-400ML/d cycles, suggesting the increased velocity during the 900ML/d peak flow scoured algal biomass.
- Algal species richness ranged between 12 and 18 for sites on the Mitta Mitta River, and was consistently lowest at the control reach that did not receive variable flows. Diatoms formed > 40% of the relative abundance of the biofilm communities at all sites, and over 80% of relative biomass at the reference site. The filamentous green algae at the upstream site in the Mitta Mitta River reduced from approximately 35% to 15% following the 900 ML/day release and at the downstream site was reduced from 50-60% to less than 1%. The relative biovolume of filamentous Cyanobacteria at the upstream Mitta Mitta site increased following the 900 ML/day, suggesting these taxa can tolerate higher velocities. These cyanobacteria are not toxic and are an important part of the biofilm community because the mucilaginous sheath that protects the cell is a source of food high in protein that can be used by benthic grazers.

Conclusions

- The water quality was good at all sites on all sample dates. Total suspended solids and turbidity levels in the Mitta Mitta were low, even during the peak flows.

- The 200-400ML/day cycles did not reduce the total biofilm biomass on cobble or artificial substrates. The repeated cycling from 200-400ML/day may be encouraging growth of some filamentous taxa that appear to be tolerant to that range of discharge and are capable of growing fast. However, water velocities of more than 1m/sec that were achieved during the 900ML/day peak were capable of scouring some of the persistent forms of algae that appear to grow readily in the 200-400 ML/day cycle.

Recommendations

- If the aim of the CRP's is to reduce total biofilm biomass, discontinuing the 200-400ML/day CRP is recommended, as this regime did not decrease the total biofilm biomass on cobble or artificial substrates and promoted the growth of taxa that are tolerant to that range in velocities.
- If the aim of the CRP's is to reduce total biofilm biomass, introducing a CRP that has a wider range of discharge (eg. 200 to at least 900ML/day) is recommended. This will disadvantage the 200 ML/day tolerant taxa, will scour some taxa and have sufficient velocity to relocate the sloughed biofilm downstream.
- If the aim of the CRP's is to promote a diverse biofilm, a cyclic release pattern where peak flows are separated by a period of at least 14 days is recommended. Decreasing the frequency of the CRP's will provide sufficient time between cycles to allow colonisation and growth of different taxa.

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1 Background

Dartmouth Reservoir on the Mitta Mitta River in north-east Victoria has a capacity of 3,906 GL and is the most upstream MDBC storage in the Murray River system. The main role of Dartmouth Reservoir is to increase water supplies to the Murray system and provide carryover storage to supplement Hume Reservoir in dry periods. Dartmouth Dam is utilised as a reserve storage, and is drawn down to meet downstream water requirements when other storages, particularly Hume Reservoir, have already been drawn well down.

There are five phases of operation:

- *Filling* - During the filling phase, minimum releases are made when there is no irrigation demand on the storage. Minimum releases (in the range of 200 to 500 ML/day) are maintained in order to maximise storage of water in the reservoir.
- *Release for water supply* - Releases for irrigation and water supply are made when required to supplement storage in Hume Reservoir to meet downstream requirements. These releases are not required every season, but when required, they usually commence in spring or summer, and may continue as late as April or May, depending on downstream requirements.
- *Transfer phase (to Hume Reservoir)* - In addition to releases for downstream requirements, transfers of water to Hume are made to provide flood mitigation and other benefits in the Mitta Mitta valley, and recreational benefit at Lake Hume. These transfers are usually made in summer and autumn.
- *Pre-release* - When the storage approaches full, pre-releases may be made to maintain airspace to assist with flood mitigation. Pre-releases are determined so that the storage will subsequently fill without affecting the security of supplies.
- *Spilling* - When the storage exceeds full supply level, flow over the spillway commences.

Variations in release rates are frequently required during the various phases of operation of Dartmouth Reservoir and power station in response to changing downstream requirements. Limits to the rates of rise and fall of the river downstream of the Regulation Dam have been adopted to provide adequate warning of river level changes, and to minimise river bank slumping.

The storage levels of Dartmouth Reservoir tend to reflect longer cycles of wet and dry periods (MDBC n.d.). Dartmouth releases are generally characterised by periods of higher flow in the Mitta Mitta (ie usually up to 900ML/day depending on demand). Minimum release from Dartmouth Dam is 200ML/day in order to conserve resources during the 'filling' phase. In wetter months there may be low releases for long periods in order to conserve water in Dartmouth (Figure 1).

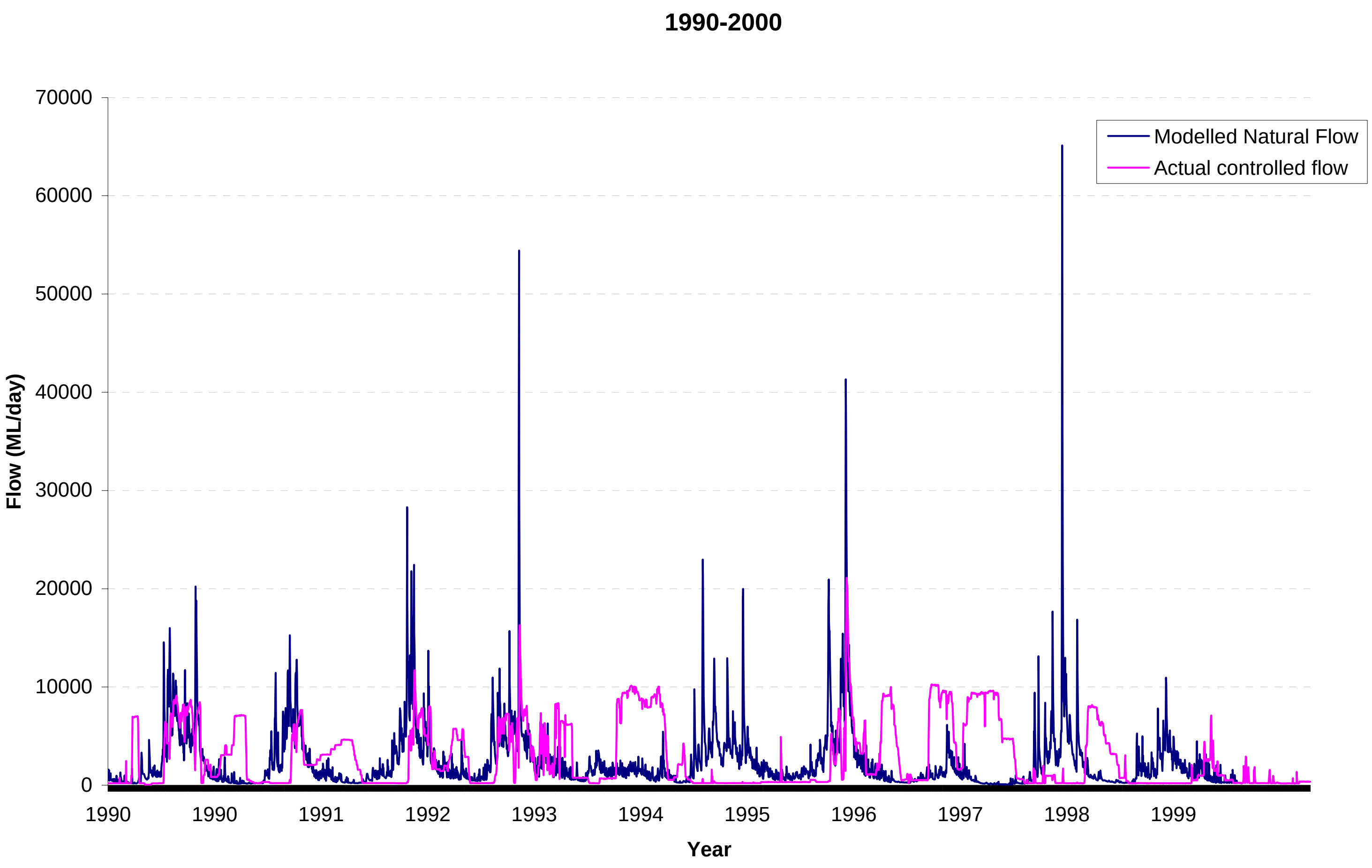

Figure 1: Historic hydrograph for the Mitta Mitta River (Colemans Gauge) illustrating modelled natural flow conditions and actual current controlled flow for the period 1990 to 2000. CRP releases began in the Mitta Mitta River in 2001 (Data source MDBC).

2 Project Objective

Charles Sturt University (CSU) was engaged by the Murray-Darling Basin Commission (MDBC) to examine water quality and environmental health indicators in relation to variable releases during a low flow period in the Mitta Mitta River in April 2006. River Murray Water (RMW) has previously introduced Cyclic Release Patterns (CRP's) into the Dartmouth Reservoir release pattern during high flow water transfer periods. The ecological responses to these CRP's have been reported by Sutherland *et al.* (2002) and Watts *et al.* (2005).

The objective of this project was to examine the responses of biofilm biomass and taxonomic diversity to cyclic flow releases in the Mitta Mitta River during a period of minimum release from Dartmouth Dam (during the 'filling' phase of operation). Biofilms are a combination of bacteria, algae, fungi and detritus that grow on submerged surfaces. They are excellent indicators because they respond more rapidly to flow changes than higher organisms. Biofilms are central to important nutrient and biogeochemical processes and are a major food resource for higher organisms including crustaceans, insects and some fish. This project focuses on biofilms because they respond to flow changes in a time frame that is appropriate for the management change.

The project aims are to:

- describe the rationale of the project design and methodology in the context of the flow conditions during the period of study;
- present hydrograph information for the event;
- interpret the monitoring results in relation to the objective and hypotheses; and
- provide flow management recommendations for future operations of this kind.

3 Project Design & Hypotheses

3.1 Study area

The study area is located in north-eastern Victoria within the upper catchment of the Murray River. Sampling was undertaken at four sites: two in the Mitta Mitta River (Sites 1 and 4 of Sutherland *et al.* 2002 and Watts *et al.* 2005), one reference site in Snowy Creek and a control site in the Buffalo River. Cobble benches were selected at each site, as these habitats undergo considerable hydrological change during a CRP through increased velocity and area of inundation. Cobble benches are a common feature along the study reach in the Mitta Mitta River and are also a feature within the reference and control rivers.

Sites 1 and 4 are located on the Mitta Mitta River downstream of Dartmouth Reservoir (Figure 2, Table 1). The Mitta Mitta River between Lake Banimboola and the confluence of Snowy Creek flows through upland and foothills habitat, with steep-sided valleys dominated by dry sclerophyll woodland. Downstream of the township of Mitta Mitta, the river flows into a wide floodplain that has been extensively cleared for agriculture and is dominated by livestock enterprises (Koehn *et al.* 1995). The riparian zone is predominately cleared in the lower reaches with occasional stands of River Red Gum (*Eucalyptus camaldulensis*) and Willows (*Salix* spp.). Snowy Creek is a major unregulated tributary of the Mitta Mitta River and has it's confluence with this river near the Mitta Mitta township (Figure 2). The flow pattern of Snowy Creek reflects rainfall and snow melt events within the creeks catchment, and is characterised by low flows in late summer and early autumn and high flows in late winter and spring. The control site is located on the Buffalo River, approximately 10 kilometres downstream of Lake Buffalo spillway near McGuffies Bridge (Figure 3, Table 1). The Buffalo River system is approximately 60 kilometres (straight line) from the Mitta Mitta River. The Buffalo River is a regulated system that under dry conditions was predicted to receive low constant flows in the range of 120-330ML/day during this study period. Gauging stations were used to obtain river flow (ML/day) and height data (metres) for each site (Table 1).

Table 1: Summary of site locations and details for the two sampling sites on the Mitta Mitta River, reference site on Snowy Creek and control site on Buffalo River.

Site	Easting	Northing	Rationale for inclusion	River gauge used to obtain discharge data
1	534206	5956959	Downstream of Lake Banimboola and upstream of the confluence with Snowy Creek. This site provides an assessment of the ecological responses in the upstream section of the Mitta Mitta River.	Colemans (downstream of Dartmouth, upstream site 1)
4	518232	5967211	Used to assess ecological response to variable flows at the downstream end of the study area.	Tallandoon (2km downstream of site 4)
Reference (Snowy Creek)	536704	5953633	Snowy Creek is an unregulated tributary of the Mitta Mitta River. To be used as a reference site.	Granite Flat (2km upstream reference site)
Control (Buffalo River)	472928	6053664	Buffalo River downstream of Lake Buffalo near McGuffies Bridge. Regulated system not receiving CRP's. To be used as a control site.	Lake Buffalo (upstream of the control site)

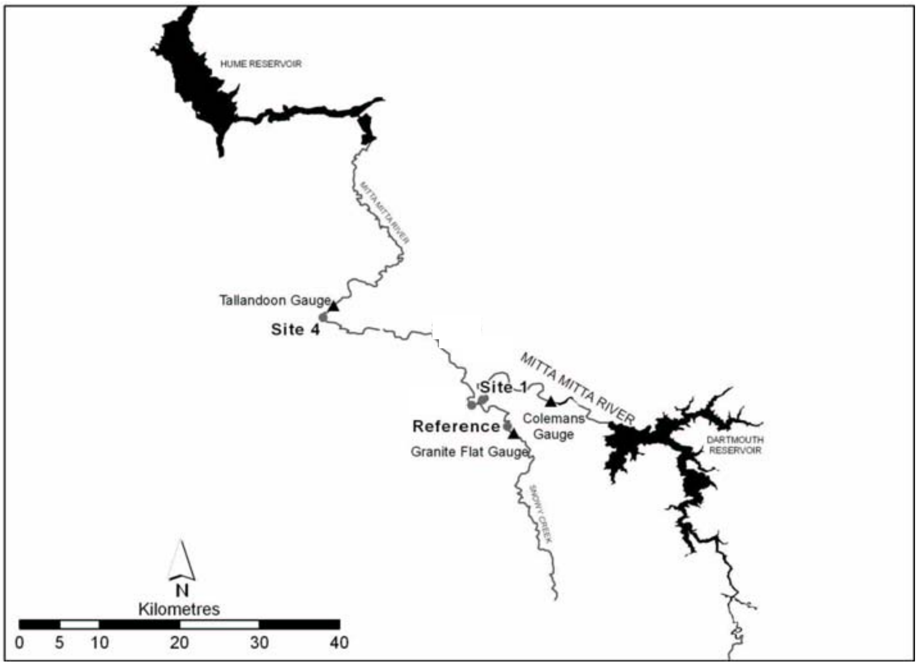

Figure 2: Location of sites 1 and 4 on the Mitta Mitta River and the reference site

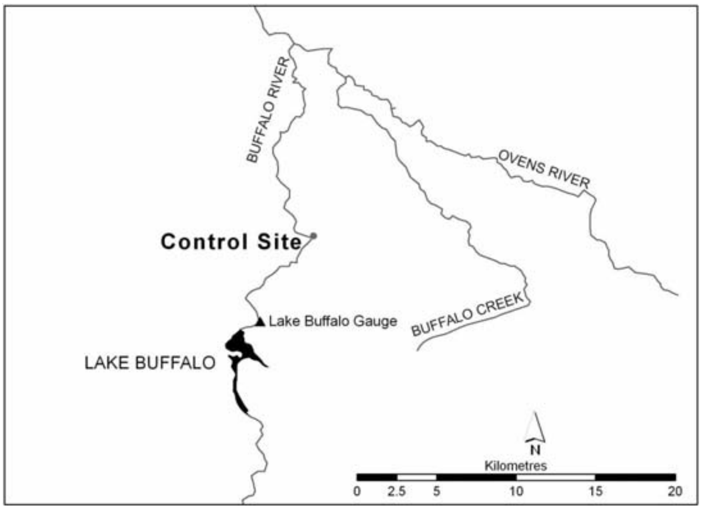

Figure 3: Location of the control site on the Buffalo River downstream of Lake Buffalo.

3.2 Sampling regime and hydrographical data

The study was undertaken over a four week period from 6th April to 4th May 2006. During the study there were four cycles released from Dartmouth Dam to the Mitta Mitta River. This included two smaller weekly cycles (approx 200-400 ML/d averaging 300 ML/d over a week at the Colemans gauge) followed by two larger weekly cycles (approx 300-900 ML/d averaging 400 ML/d over a week at the Colemans gauge) (Table 2, Figure 4). The cyclic flows resulted in only a slight increase (0.5 to 1 metre) in inundation of the cobble bars at site 1 and site 4 in the Mitta Mitta River (Plates 1 and 2). Sampling was undertaken on nine occasions. Samples were collected each Thursday at the lowest discharge of each cycle and each Sunday at the peak discharge of each cycle (Table 2, Figure 4).

Table 2: Sampling dates, flow rates (at Coleman's and Tallandoon gauges) and sample type during the 2006 CRP event within the Mitta Mitta River**.**

Sample number	Sample date	Flow at Colemans gauge (ML/d)	Flow at Tallandoon gauge (ML/d)	Time of cycle
1	6/4/06	190	480	
2	9/4/06	410	625	peak
3	13/4/06	218	430	
4	16/4/06	410	703	peak
5	20/4/06	211	525	
6	23/4/06	932	1112	peak
7	27/4/06	325	573	
8	30/4/06	932	1087	peak
9	4/5/06	320	660	

In the three months prior to the study period (January – March) the release from Dartmouth Reservoir was variable but at low discharge rates (Figure 4). During this period there were 8 smaller cyclic releases of approximately 200 to 400 ML/d at the Colemans gauge and also three larger transfers (1000ML/d, 2000ML/d and 1500ML/d at the Colemans gauge) (Figure 4). There was a rainfall event that resulted in a small rise in discharge in Snowy Creek on the 15/4/06 between sample dates 3 and 4 (Figure 5). This resulted in a slight increase in the discharge at the Tallandoon gauge in the Mitta Mitta River on 16/4/06. The discharge in Buffalo River was relatively constant throughout the study period (Figure 5).

3.3 Study context

There are two aspects of the design of this study that need to be considered when interpreting the results. Firstly, the short duration and timing of the study (4 weeks in Autumn) means that we can provide only a snapshot of the biofilm response within a much longer period of cyclic flows, and the condition of the biofilm prior to the first 200-400ML/day cycle in February 2006 is unknown. Secondly, the consecutive nature of the two smaller weekly cycles (200-400ML/day) followed by two larger weekly cycles (300-900ML/day) limits the ability to determine if there are independent responses of biofilms on cobbles to each of the different cycles. As field studies of this type can never be truly independent, we have used an experimental approach. Artificial substrates were deployed at each site at the beginning of the study (6/4/06) and the beginning of the 300-900ML/day cycles (20/4/06). The differences in newly established biofilms will be compared between the two 14 day periods, removing the influence of antecedent conditions on biofilm formation.

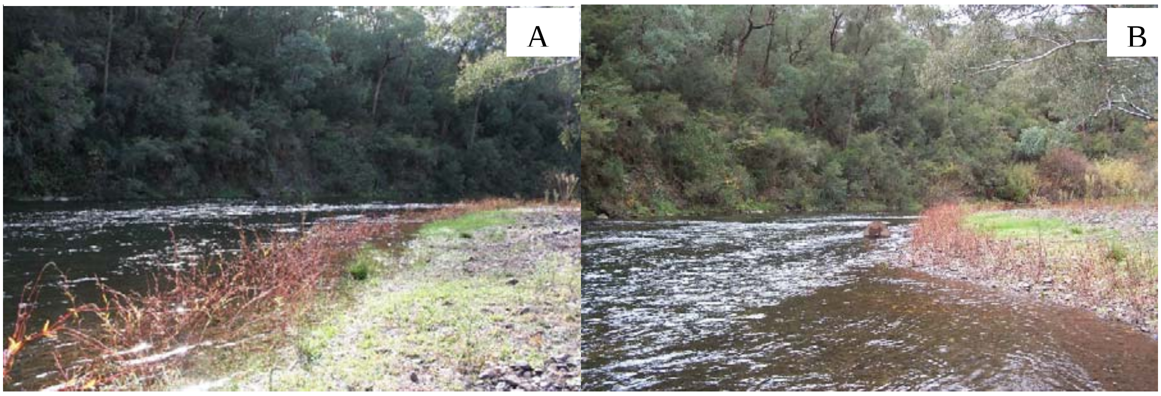

Plate 1: Mitta Mitta River at site 1 (a) 23rd April at 932 ML/day at Colemans Gauge and (b) 4th May at 320ML/day at Colemans Gauge.

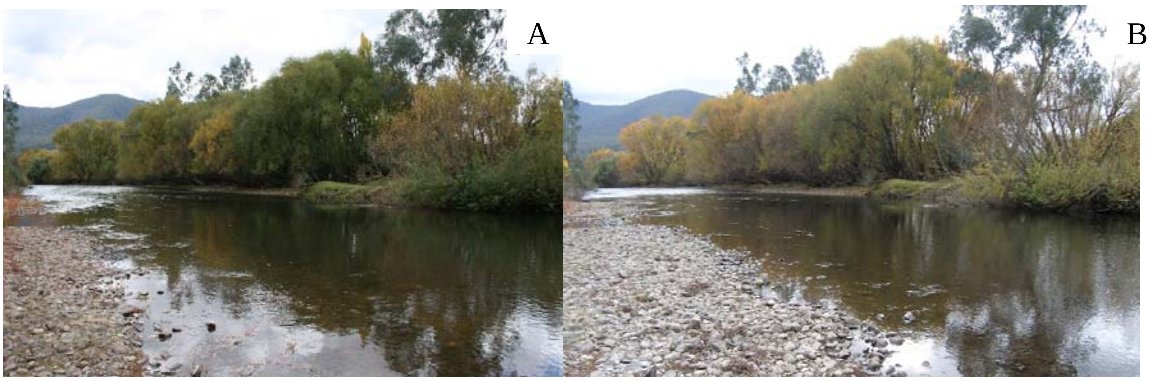

Plate 2: Mitta Mitta River at site 4 (a) 23rd April at 1112ML/day at Tallandoon Gauge and (b) 4th May at 660ML/day at Tallandoon Gauge.

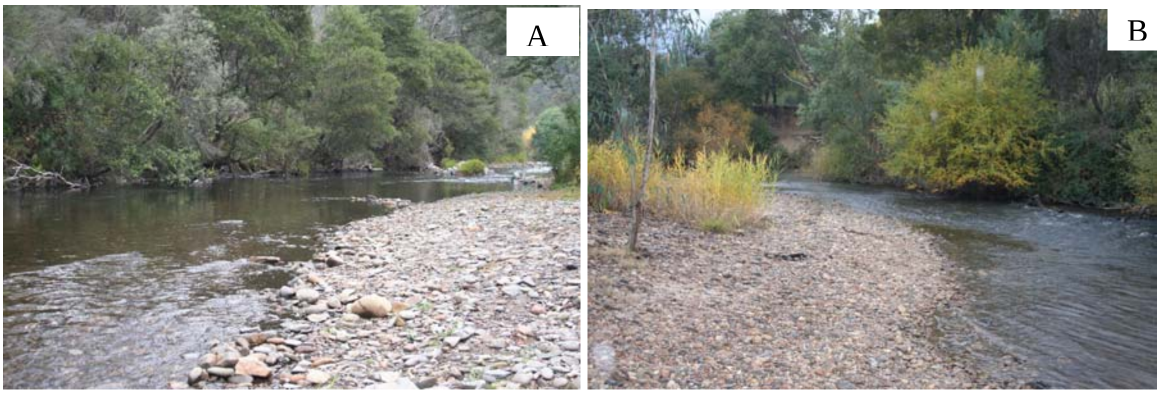

Plate 3: (a) Reference site on the unregulated Snowy Creek and (b) control site on the regulated Buffalo River.

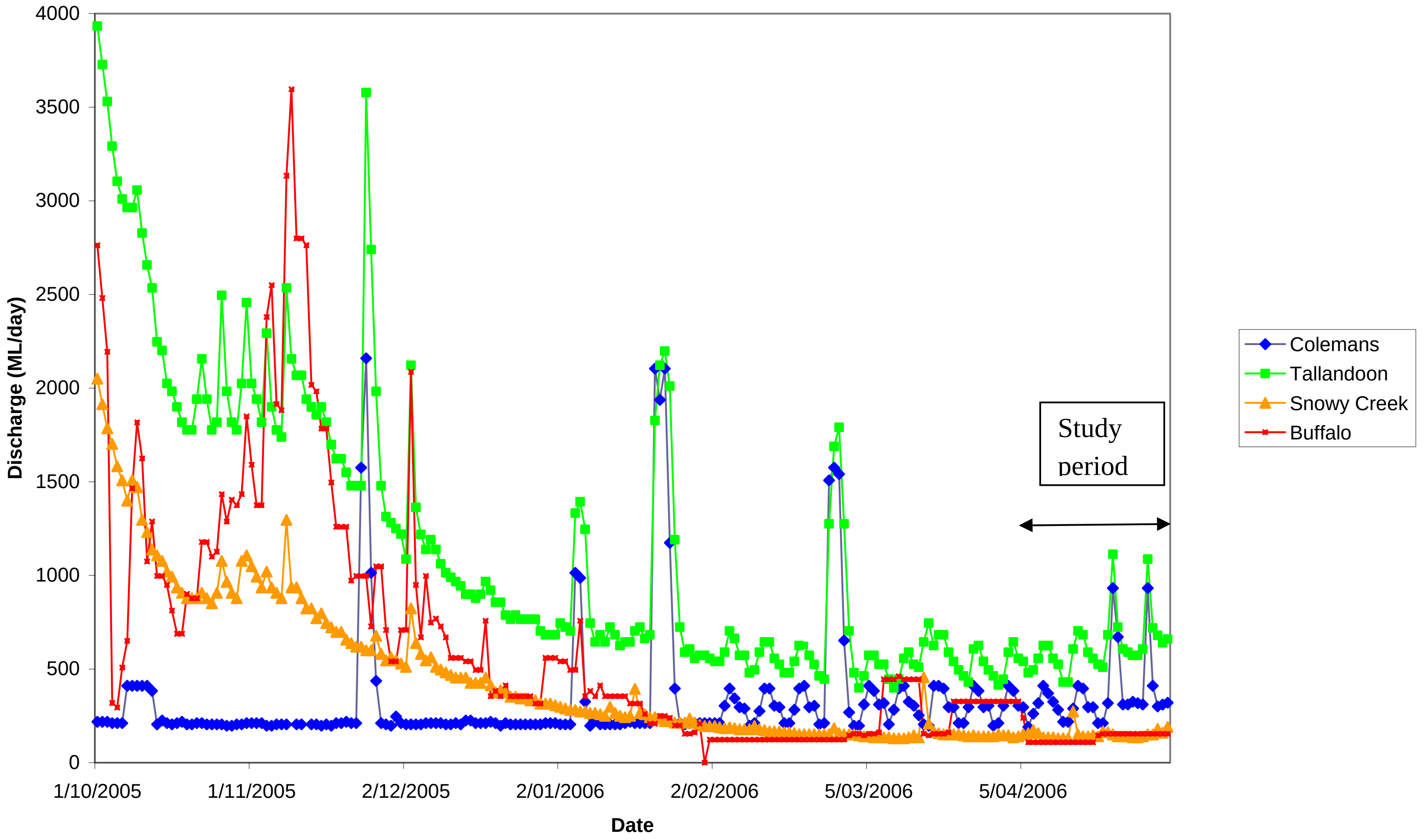

Figure 4: Hydrograph for the Mitta Mitta River recorded at Tallandoon and Colemans gauging stations, Snowy Creek recorded at Granite Flat gauging station, and Buffalo River recorded at Lake Buffalo gauging station (McGuffies Bridge) for the period 1/10/2005 to 4/5/2006.

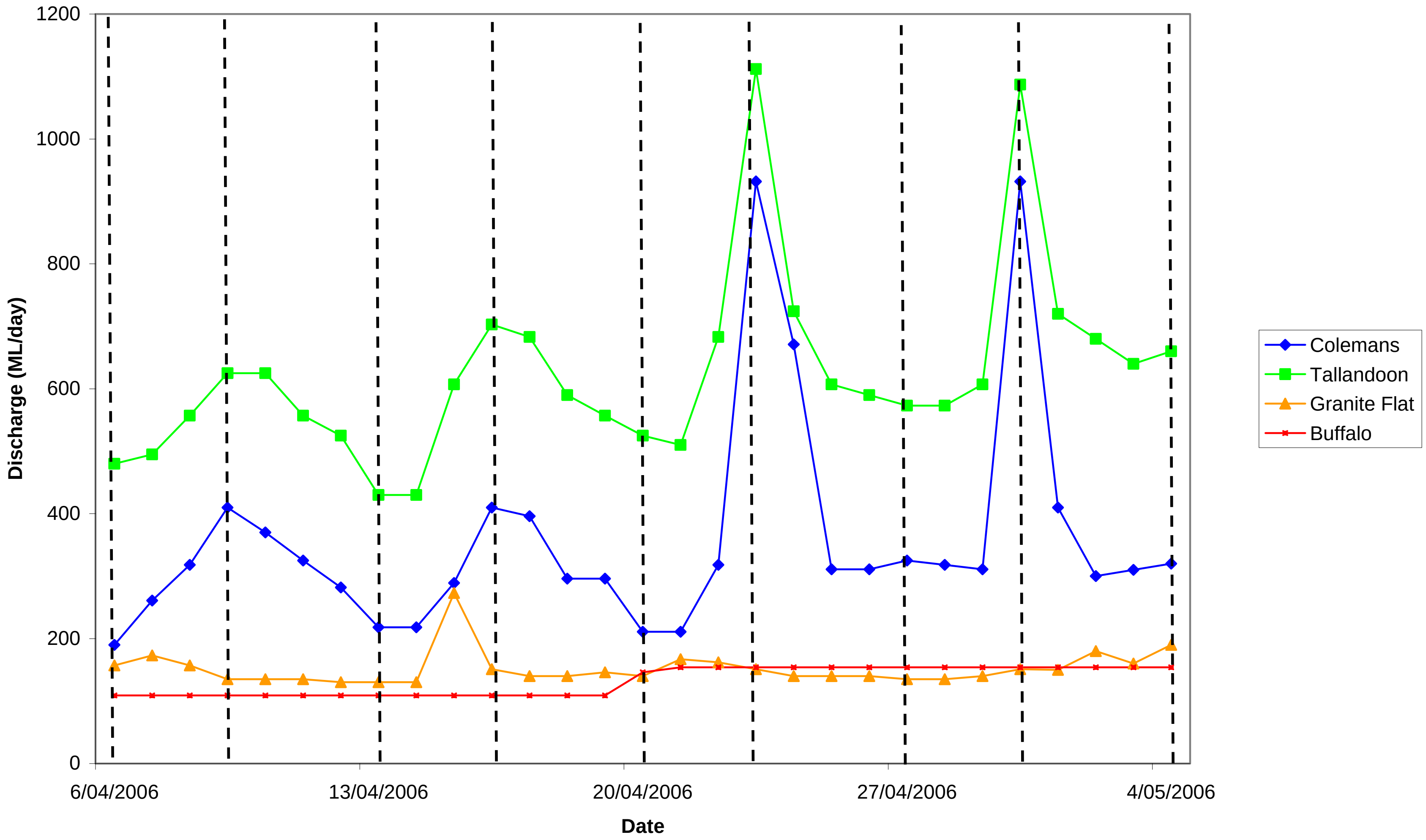

Figure 5: Sampling events and discharge period at the four study sites during the period from 6th April to 4th May 2006. Dashed lines indicate sampling dates

3.4 Monitoring indicators and hypotheses

The following parameters were monitored at each site:

- Water quality;
- Biofilm biomass and composition; and
- Water velocity.

3.4.1 Water quality

The following water quality parameters were measured on each sample date:

- Total Suspended Solids (TSS)
- Temperature
- Conductivity
- Dissolved Oxygen (DO)
- pH
- Turbidity

The following hypothesis will be tested:

- That the water column concentration of total suspended solids will be higher during the peak of each 900ML/day CRP compared to the peak of the 400ML/day CRP as a result of the increased riverbank and floodplain inundation, in channel re-suspension and scouring of biofilms.

3.4.2 Biofilm biomass and taxonomic composition

The total biomass (dry weight), organic biomass (ash free dry weight) and algal biomass (Chlorophyll-*a*) and biofilm algal species composition will be assessed from permanently inundated cobbles collected on each sample date.

The following hypotheses will be tested:

- That total, organic and algal biomass on cobbles will decrease during the peak of the 900ML/day CRP peak due to scouring of biofilms from increased velocity.
- There will be less total, organic and algal biomass on cobbles during the 300-900ML/d cycles compared to the 200-400ML/d cycles.
- The 900ML/day CRP will change the community composition of biofilm and promote early successional algal taxa on cobbles due to scouring from increased velocity.

The total, organic and algal biomass will be assessed from artificial substrates that were deployed at each site at the beginning of the study period (6/4/06) and the beginning of the 300-900ML/day cycles (20/4/06).

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The following hypothesis will be tested:

- There will be less total, organic and algal biomass established on artificial substrates during the 14 days of 300-900ML/d cycle compared to the 14 days of 200-400ML/d cycle due to scouring from increased velocity during the 900ML/d peak flow.

4 Field and laboratory methods

4.1 Field methods

Three replicate water samples were taken from flowing surface waters at each study site on each sampling event for determination of total suspended solids. A HydroLab was placed near the water surface at each site at each sampling date to obtain spot measures of the temperature, specific conductivity, dissolved oxygen, pH and turbidity of the water.

On each sampling occasion 6 cobbles (ranging between 12 and 25cm diameter) were collected from each site, placed in labelled sealed plastic bags and stored in the dark. The area from which the cobbles were selected was in the central third of the channel at each site so that all sampled cobbles remained permanently inundated throughout the study period.

Artificial substrates were deployed at each site at the beginning of the study period (6/4/06) and the beginning of the 300-900ML/day cycle (20/4/06). The artificial substrates consisted of six, 5 x 5cm unglazed ceramic tiles (total surface area 150 cm^2) attached using silicone to a black Perspex base (20 x 15cm, 300cm^2). They were secured to the stream bed by two tent pegs. The artificial substrates deployed on 6/4/06 were retrieved on 20/4/06 after 14 days of 200-400ML/day cycles and those deployed on 20/4/06 were retrieved on 4/5/06 after 14 days of 300-900ML/day cycles. Unfortunately the substrates placed in the Buffalo River were stolen over the Easter holiday period so no data were obtained for this site.

The water velocity and water depth were measured with a current meter at the location where each of the six replicate cobbles were sampled and where each artificial substrate was retrieved.

4.2 Laboratory methods

4.2.1 Water quality

TSS was measured from the water samples using the methods outlined in Watts *et al.* (2005). TSS was calculated using the dry weight obtained by filtering water using 75μm glass fibre filter papers. TSS was calculated as the total dry weight of filtrate and estimated as g/m^3.

4.2.2 Biofilm biomass and taxonomic composition

The biofilm was scrubbed from each cobble or artificial substrate into 200 millilitres of distilled water using a soft toothbrush within 48 hours of field collection. Sub-samples were removed from the 200 millilitre residue for determination of Chl-*a* (filtered through a GFF 75µm filter), the amount filtered was recorded and a 10 millilitre sample for the assessment of taxonomic composition was stored in Lugols solution.

Using pre-ashed GFF 75µm filter papers a recorded amount of the solution was filtered, each biomass sample was dried at 80°C for 24 hours, weighed, combusted for 4 hours at 500°C and reweighed. All samples were weighed to four decimal places and converted to dry weight (DW) and ash free dry weight (AFDW). Chlorophyll-*a* was determined following Tett *et al.* (1975). Samples were placed in 8 millilitres of methanol containing 150 milligrams magnesium carbonate to prevent premature acidification, extracted for 18 hours at 4°C, transferred to a 70°C water bath and boiled for 2 minutes. Samples were centrifuged at 4500rpm for 3 minutes and optical densities at 750 and 666λm were measured pre- and post-acidification (1M HCl) using a UV/Visible Spectrophotometer.

Each cobble was measured for colonisable rock surface area (CRSA) by covering the exposed surface area of the rock (excluding the buried surface) with aluminium foil (after Doeg & Lake 1981). CRSA measurements were used to standardise biofilm dry weight (DW) and ash free dry weight (AFDW) to g/m^2 and Chl-*a* to mg/m^2. Percent organic matter was calculated as the proportion of AFDW to DW and converted to a percentage to standardise across sites and dates.

Taxonomic composition of the algae was estimated by calculating the biovolume of the first 750 cells counted by light microscopy at 400x magnification of three replicate biofilm samples from all sites for all dates. The cell dimensions and approximated geometric shape of each taxon were recorded and used to calculate the biovolumes using the biovol program (Hillebrand *et al*. 1999). Biovolume provides a more accurate estimate of relative abundance than cell number as it standardises results by cell size and removes complications associated with species such as filamentous Cyanobacteria which do not have individual cells.

Taxonomy was confirmed at 1000x magnification for some specimens. Biovolume of each taxon was converted to a relative percentage of the total biovolume. Relative biovolume gives a good assessment of broad taxonomic shifts in biomass. The algae were grouped by division into Bacillariophytes (diatoms), Chlorophytes (green algae), filamentous Cyanobacteria (blue-green algae) and Rhodophytes (red algae). The algal cells were mainly identified to genus. Species were named where sufficient detail was available from microscopy, and keys were available for the genus.

4.3 Data analyses

One factor General Linear Models were used to examine differences in biofilm biomass between sample dates using SPSS for Windows Release 12.0.2 (SPSS Inc 2004). Data for biofilm total, organic and algal biomass were assessed for normality and homogeneity of variances using Levene's test of Homogeneity. Heteroscedastic data were log-transformed to improve normality and homogeneity of variances. Post-hoc tests using the Bonferroni-type correction were used to test the effect of habitat types and sample times.

5 Results

5.1 Water quality

Water quality hypothesis

The water column concentration of suspended solids will be higher during the peak of each 900ML/day CRP compared to the peak of the 400ML/day CRP as a result of the increased riverbank and floodplain inundation, in channel re-suspension and scouring of biofilms.

There was an increase in total suspended solids (TSS) during the first and second CRP events (peak discharge approx 400ML/day at Colemans gauge) at both of the Mitta Mitta River sites (Figure 6). TSS levels were consistently higher at site 4 (Figure 6). However, TSS levels were lower during the peak of the third and fourth cycles (approx 900ML/day peak discharge at Colemans gauge). Therefore, these results do not support the hypothesis that TSS will be higher during the peak of each 900ML/day CRP compared to the peak of the 400ML/day CRP. This pattern may have occurred because after several months of cyclic flows (Figure 5) there may have been a reduced amount of sediment available to be re-suspended during the later cycles, as TSS levels in the Mitta Mitta even during the peak flows were generally low for this river style. This is confirmed by relatively low turbidity at all sites during the study period. In the Mitta Mitta River, turbidity ranged from 2.5 to 16.2 NTU at site 1 and 4.8 and 22.2NTU at site 4. In addition, the minimal increase in riverbank and floodplain inundation (Plate 1 and 2) resulting from these cyclic flows would have limited the availability of material for re-suspension. Most good condition upland streams have low turbidity between values of 2 and 25 NTU (ANZECC and AMCANZ 2000)

The water velocities were measured at the locations where each cobble was collected. Water velocities at site 1 in the Mitta Mitta River ranged from 0.52 m/sec (6/4/06) to 1.05m/sec (23/4/06). The water velocity at site 1 responded as expected, with higher velocities on the peak discharge of each CRP and lower velocities on lowest discharge sample dates (Figure 7). Velocities at site 4 were slightly lower than at site 1 on some sample dates and ranged from 0.41 (6/4/06) to 1.09 m/sec (23/4/06). Velocities of greater than 1m/sec have been shown to reduce the biomass of filamentous algae, whereas lower velocities can promote algal growth (see review in Ryder *et al.* 2006).

Spot measurements of water temperature in the Mitta Mitta River ranged from 9.9 to 13.1°C at site 1 and between 11.1 and 13.6 °C at site 4. Water temperatures were higher at the control site in Buffalo River (average 14.9°C) and lower at the reference site in Snowy Creek (average 9.2°C) than those recorded in the Mitta Mitta River.

Water conductivity was very low and relatively constant at all sites on the Mitta Mitta during the study period. Mean conductivity was 0.048mS/cm at site 1, 0.047 mS/cm at site 4, 0.040 mS/cm in Snowy Creek and 0.041 mS/cm in Buffalo River.

The percent concentration of dissolved oxygen was good at all sites on all sample dates. At site 1 it ranged between 93.7% (6/4/06) and 100.2% (23/4/06), at site 4 ranged between 93.7% (13/4/06) and 102% (27/4/06). In Snowy Creek the percent dissolved oxygen ranged from 103.6% (6/4/06) to 112.7% (13/4/06) and in Buffalo River ranged from 93.6%(6/4/06) to 102.4% (23/4/06).

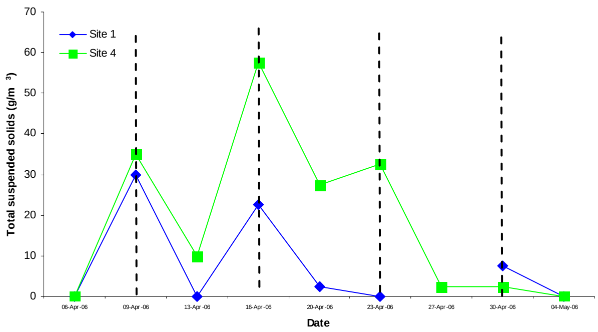

Figure 6: Water column concentrations of total suspended solids (g/m^3) at sites 1 and 4 on the Mitta Mitta River. Dashed lines indicate the peak of each cycle.

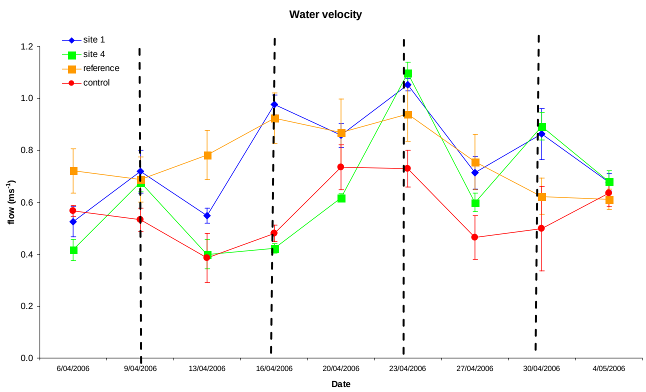

Figure 7: Water velocity (ms^{-1}) at 2 sites on the Mitta Mitta River, a reference site (Snowy Creek) and control site (Buffalo River). Water velocity was measured at six locations where cobbles were collected on each date. Dashed lines indicate the peak of each cycle.

Summary of water quality results

- The water quality was good at all sites on all sample dates and would not have negatively impacted on biofilm accumulation. Turbidity and water conductivity were low at all sites during the study period and dissolved oxygen was high at all sites.
- Water velocities were higher on the peak of each CRP and lower on the troughs of each cycle. Water velocities at site 1 ranged from 0.52 m/sec (6/4/06) to over 1.05m/sec (23/4/06), a velocity sufficient to scour filamentous algae.
- There was an increase in total suspended solids on the peak of the first and second CRP events at both of the Mitta Mitta River sites but not during the third and fourth cycles. Thus the hypothesis that TSS would be higher during the peak of the 900ML/day CRP compared to the peak of the 400ML/day CRP was not supported. After several months of cyclic flows there may have been a reduced amount of sediment available to be re-suspended during the later cycles. In addition, the minimal increase in riverbank and floodplain inundation may have limited the availability of material for re-suspension.

5.2 Biofilm biomass and taxonomic composition

Biofilm biomass hypotheses (cobbles)

- That total, organic and algal biofilm biomass on cobbles will decrease during the peak of the 900ML/day CRP peak due to scouring of biofilms from increased velocity.
- There will be less total, organic and algal biomass on cobbles during the 300-900ML/d cycle compared to the 200-400ML/d cycle.

5.2.1 Biofilm total, organic and algal biomass on cobbles

The total biomass of biofilms on cobble at site 1 and 4 in the Mitta Mitta River generally increased throughout the 4 week study period from approximately 20g/m^2 (6/4/06) to 42 g/m^2 and 58g/m^2 at sites 1 and 4 respectively (4/5/06) (Figure 8). The values at the end of the study period were similar to biofilm dry weights observed in a previous study where there was 53.74 g/m^2 at site 4 during a constant discharge of 1100 ML/d (Watts *et al*. 2005). The gradual increase in total biomass over the 4 week study period suggests there was no major scouring and sloughing of total biofilm biomass in response to the higher velocity flows of either of the CRPs. The organic biomass on cobble at site 1 and 4 in the Mitta Mitta River showed a similar increase throughout the 4 week study period (Figure 9).

There were differences in algal biomass (Chlorophyll-*a*) at site 1 and site 4 in the Mitta Mitta River during the study period. At site 1 the algal biomass was initially approximately 100mg/m^2, then increased to 260mg/m^2 during the 200-400ML/day CRP but decreased to approx 165mg/m^2 during the last 2.5 weeks of the study period (Figure 10). In contrast, the algal biomass at site 4 showed a gradual increase over the study period from approx 100mg/m^2 to approx 315mg/m^2 (Figure 10). In a previous study the algal biomass was as high as 300 mg/m^2 at site 4 during a period of constant flows of approximately 2600ML/day (Watts *et al*. 2005). It is possible to observe a reduction in algal biomass with no concurrent reduction in total biomass because total biomass is driven by silt and the non-chlorophyll algal components of biofilms. In addition, algal biomass is measured in mg/m^2 whereas total biomass is measured in g/m^2. Thus, a significant change in algal biomass between samples may not be detectable in total biomass.

Biofilm total, organic and algal biomass was low at the control site throughout the study period (Figures 8, 9, 10). Biofilm total, organic and algal biomass was initially low at the reference site but increased rapidly at this site over the final 10 days of the study to a maximum value of 44g/m^2 total biomass and 446mg/m^2 algal biomass (Figures 8 and 10). In a previous study the biofilm total biomass on cobbles at the reference site in Snowy Creek did not exceed 5.11 g/m^2 and algal biomass was generally less than 40mg/m^2 (Watts *et al*. 2005). This rapid increase in biomass may be a response to the scouring event on 13/4/06. The dominant algal taxon in this period was *Melosira varians*, a chain forming (filamentous) diatom that can grow rapidly in low flow conditions.

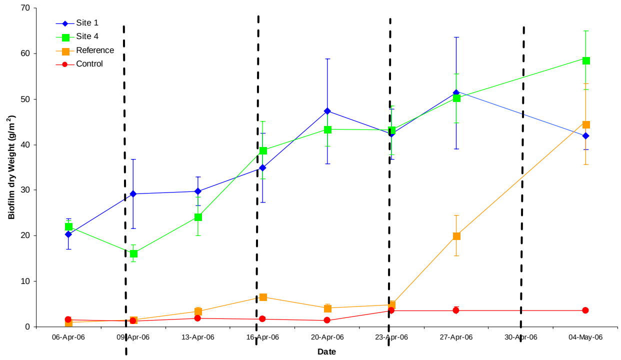

Figure 8: Biofilm total biomass (dry weight g/m^2) on permanently inundated cobble at sites 1 and 4 in the Mitta Mitta River, the reference Snowy Creek and control Buffalo River (mean ±SE, n=6). Dashed lines indicate the peak of each cycle.

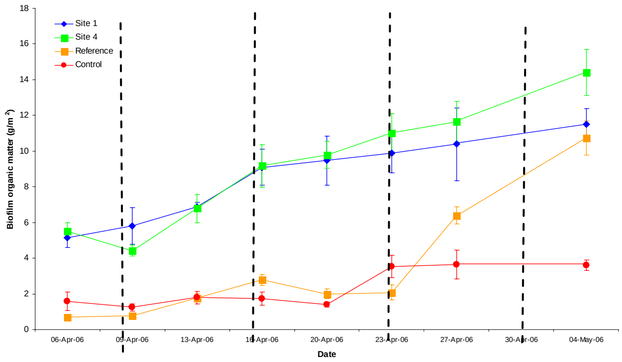

Figure 9: Biofilm organic biomass (AFDW g/m^2) on permanently inundated cobble at sites 1 and 4 on the Mitta Mitta River, the reference Snowy Creek and control Buffalo River (mean ±SE, n=6). Dashed lines indicate the peak of each cycle.

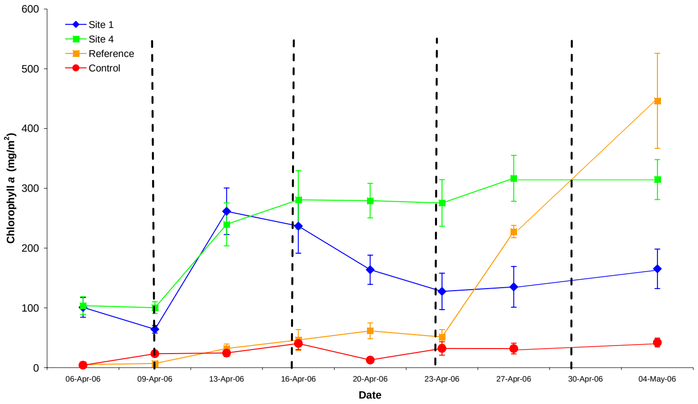

Figure 10: Biofilm algal biomass (Chlorophyll-*a* mg/m²) on permanently inundated cobble at sites 1 and 4 on the Mitta Mitta River, the reference Snowy Creek and control Buffalo River (mean ±SE, n=6). Dashed lines indicate the peak of each cycle.

Summary of biofilm biomass results on cobble

- Total and organic biomass of permanently inundated biofilms on cobble in the Mitta Mitta River generally increased throughout the 4 week study period. Thus the hypothesis that total biofilm biomass on cobbles would decrease during the peak of the 900ML/day CRP peak due to scouring of biofilms from increased velocity was not supported. This suggests there was no major flow-related loss of total biofilm biomass in response to the higher velocity flows of the CRPs. The biomass at the end of the study period was similar to that observed during a period of constant discharge in a previous study.
- Algal biomass on cobbles decreased at site 1 during the last 2.5 weeks of the study. This may have been due to scouring of the filamentous diatom *Melosira varians*, thus changing the relative biovolume to favour blue green algae and green algae. Thus the hypothesis that there will be less algal biomass on cobbles during the 300-900ML/d cycle compared to the 200-400ML/d cycle was supported.

5.2.2 Biofilm total, organic and algal biomass established on artificial substrates

Biofilm biomass hypothesis (artificial substrates)

- There will be less total, organic and algal biomass established on artificial substrates during the 14 days of 300-900ML/d cycle compared to the 14 days of 200-400ML/d cycle due to scouring from increased velocity during the 900ML/d peak flow.

After 7 days of inundation there was only a small increase in biofilm biomass on the artificial substrates (Figure 11). There was an increase in total biomass on the artificial substrates over the 28 day study period at all sites (Figure 11, Plate 4). This supports the observation of an increase in total biomass on the cobbles (Figure 8) and suggests there was no major scouring and sloughing of total biofilm biomass in response to the higher velocity flows of the CRPs. There was initially an increase in organic biomass at site 1 then it remained constant during the 300-900 ML/day cycle (Figure 11).

There was initially an increase in algal biomass at site 1 before it decreased during the 300-900 cycles (Figure 11). This supports the observation of a decrease in algal biomass on the cobbles during the 300-900ML/day cycles (Figure 10) and suggests that scouring of biofilms may have occurred from increased velocity.

There was no difference in the total and organic biomass established on the artificial substrates during the 14 days of the 200-400ML/day cycles (6/4/06 to 20/4/06) compared to that established during the 14 days of the 300-900ML/day cycles (20/4/06 to 4/5/06) (Figure 12). Thus, there was no difference in extent of biofilm scouring of the total and organic biomass between these two 14 day periods.

The algal biomass that established on the artificial substrates at site 1 was significantly less during the 300-900 cycle compared to the 14 days of the 200-400ML/day cycle (Figure 12). This supports the observations on the cobbles (Figure 13) and suggests that the 300-900ML/day CRP may have a better capability to scour the algal biofilms from hard substrates. The taxonomic composition of the algae on the artificial substrates was not examined for this study. However, it is likely that the reduction in algal biomass on the artificial substrates reflected the changes observed on the cobbles and was due to scouring of the filamentous diatom *Melosira varians*.

Summary of biofilm biomass on artificial substrates

- There was an increase in total biomass on the artificial substrates over the 28 day study period at all sites. This is consistent with the observed increase in total biomass on the cobbles over the study period and suggests there was no flow related loss of biofilm biomass in response to the higher velocity flows of the CRPs.
- There was no difference in total biomass established on artificial substrates at site 1 and site 4 in the Mitta Mitta River during the 14 days of 300-900ML/d cycle compared to the 14 days of 200-400ML/d cycle. Thus, there was no difference in extent of scouring of total biomass between these two 14 day periods.
- The algal biomass from artificial substrates at site 1 after 14 days of the 300-900ML/d cycles was significantly less that the biomass that established during the 14 days of 200-400ML/d cycles, suggesting the increased velocity during the 900ML/d peak flow scoured algal biomass.

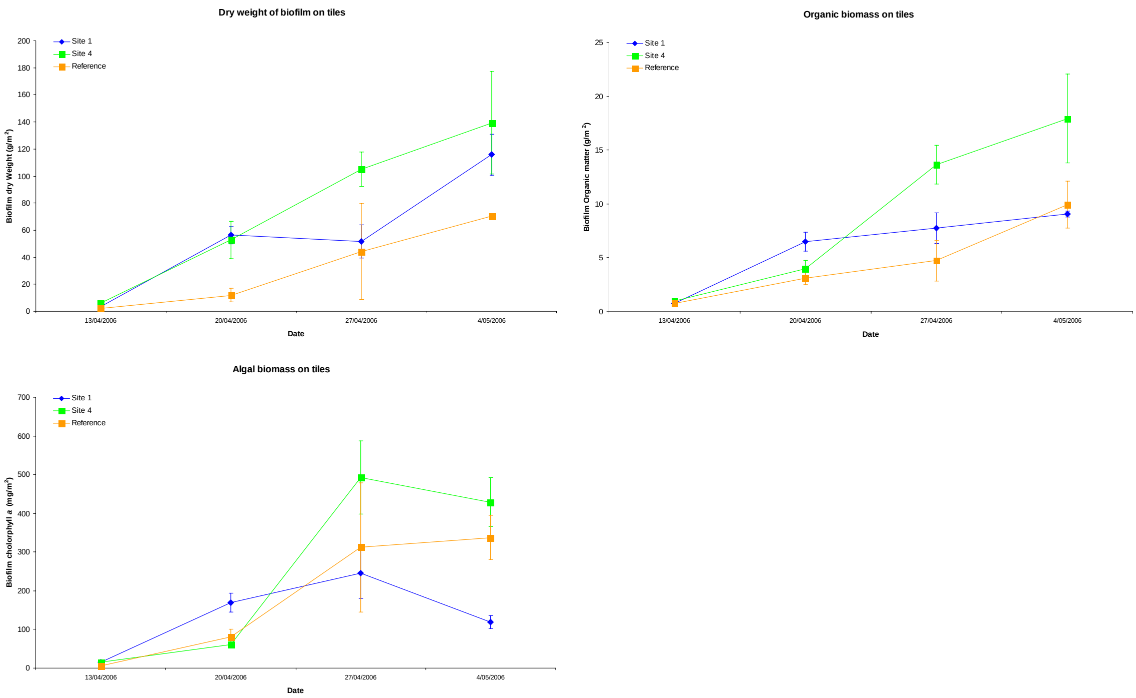

Figure 11: Biofilm total biomass (dry weight g/m²), organic biomass (AFDW g/m²) and algal biomass (Chlorophyll-*a* mg/m²) on artificial substrates at sites 1 and 4 in the Mitta Mitta River and the reference Snowy Creek (mean ±SE, n=4). No data were available for Buffalo River because the artificial substrates deployed there were washed away or stolen.

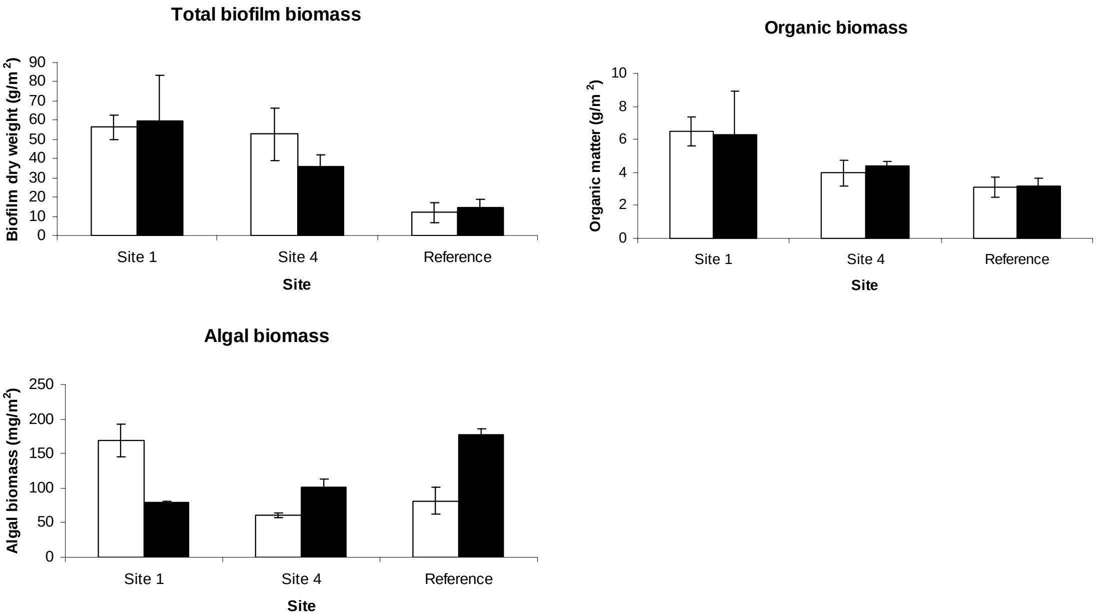

Figure 12: Biofilm biomass on artificial substrates after 14 days immersion at sites 1 and 4 in the Mitta Mitta River and the reference site in Snowy Creek. a) total biomass, b) organic biomass and c) algal biomass. Open bars are for the 14 days from 6/4/06 to 20/4/06

(discharge range 190-410ML/day at Colemans gauge). Black bars are for the 14 days from 20/4/06 to 4/5/06 (discharge range 211–932ML/d at the Colemans gauge) (mean ±SE).

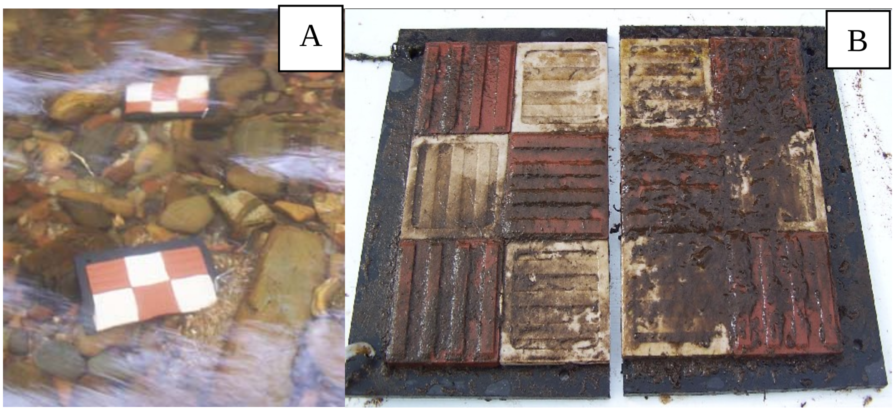

Plate 4. Artificial substrates. **(**a) clean artificial substrates immediately after deployment in Snowy Creek. (b) Biofilm established on artificial substrates at site 4 in the Mitta Mitta River after 14 days immersion from 20/4/06 to 4/5/06 (left) and 28 days immersion from 6/4/06 to 4/5/06 (right).

5.2.3 Biofilm algal species composition

Biofilm algal composition hypothesis

- The 900ML/day CRP will change the community composition of algal biofilm and promote early successional algal taxa on cobble substrate due to scouring from increased velocity.

Sixty algal taxa were identified from the Mitta Mitta River, control and reference site during the study period (Appendix 2). Taxa included 40 Bacillariophytes (diatoms), 9 Chlorophytes (green algae), 10 filamentous Cyanobacteria (blue-green algae) and one Rhodophyte (red algae) (Appendix 2). Algal species richness ranged between 12 and 18 for sites on the Mitta Mitta River, and was consistently lowest at the control reach that did not receive variable flows. Snowy Creek (reference) had a taxa range from 3 to 12, reflecting the disturbance due to high flows early in the study (Figure 13).

Red algae are generally found associated with excellent water quality, and were only found at site 1 during the 200-400 cycles (Figure 14). The taxa *Batrachospermum* (found only at Site 1) is most common in moderately flowing streams and not tolerant of low-flow environments. Common green algal taxa such as *Drapnaldia* (branching filamentous), *Oedogonium* (filamentous) and *Scenendesmus* (colonial) were found at all sites except the control, whereas taxa indicative of late successional species such as *Spirogyra* (filamentous green) were found only at Site 4 and control site. The most cosmopolitan and abundant taxa were the diatom *Gomphonema clavatum* that was found at all sites except Site 1, and the filamentous blue-green taxa *Gleotrichia* and *Oscillatoria* found at all sites.

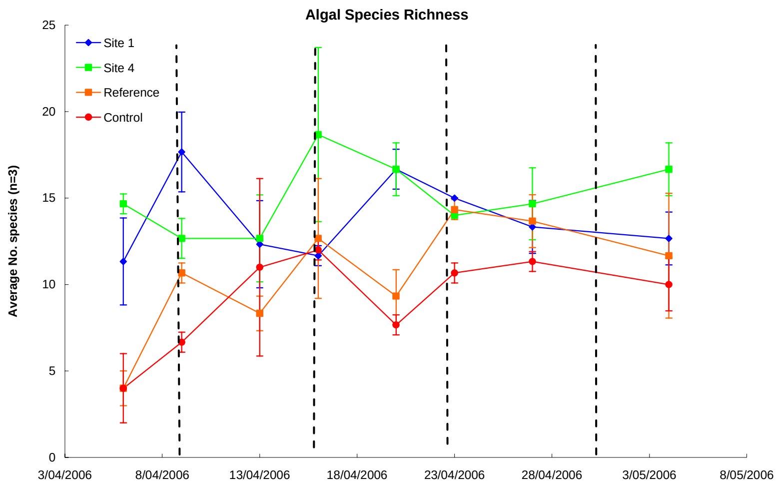

Figure 13: Mean algal species richness (mean ± s.e.) for the sample sites during the period 6/4/06 to 4/5/06. Dashed lines indicate the peak of each cycle.

Diatoms formed > 40% of the relative abundance of the biofilm communities at all sites for the duration of the study. Diatoms formed >80% of relative biomass at the reference site after an initial dominance of Cyanobacteria (53%) that was scoured by a catchment driven a river rise on 13/4/06 (Figure 14).

At site 1, the red alga *Batrachospermum* formed 20% of biomass on initial sampling but was less than 2% after the 400 ML/day peak on 13/4/06, and was absent from the biofilms after the 900 ML/day peak (Figure 14). The biofilm at site 1 comprised 32% Green algae (predominantly filamentous taxa) on 22/4/06 and was reduced to approximately 15% following the 900 ML/day release. However, Cyanobacteria (again predominantly filamentous taxa) increased in relative abundance following the 900ML/day release peaking at 35% by the end of sampling, suggesting these taxa can tolerate higher velocities. These cyanobacteria are not toxic and are an important part of the biofilm community because the mucilaginous sheath that protects the cell is a source of food high in protein that can be used by benthic grazers.

Green algal taxa dominated the biofilm (50-60%) at site 4 at all times other than the peak flows of each cycle, with a substantial reduction in relative biomass to <1% after the two 900ML/day peak flow release patterns. Cyanobacteria reached 50% of relative biomass at the control site on 13th June, being replaced by Green algal taxa by the end of the study (51%)(Figure 14).

Due to the stable flows at the control site, variations in relative biomass of the major taxa are most likely attributed to natural sloughing of filamentous taxa or variable grazing by micro and macro invertebrates.

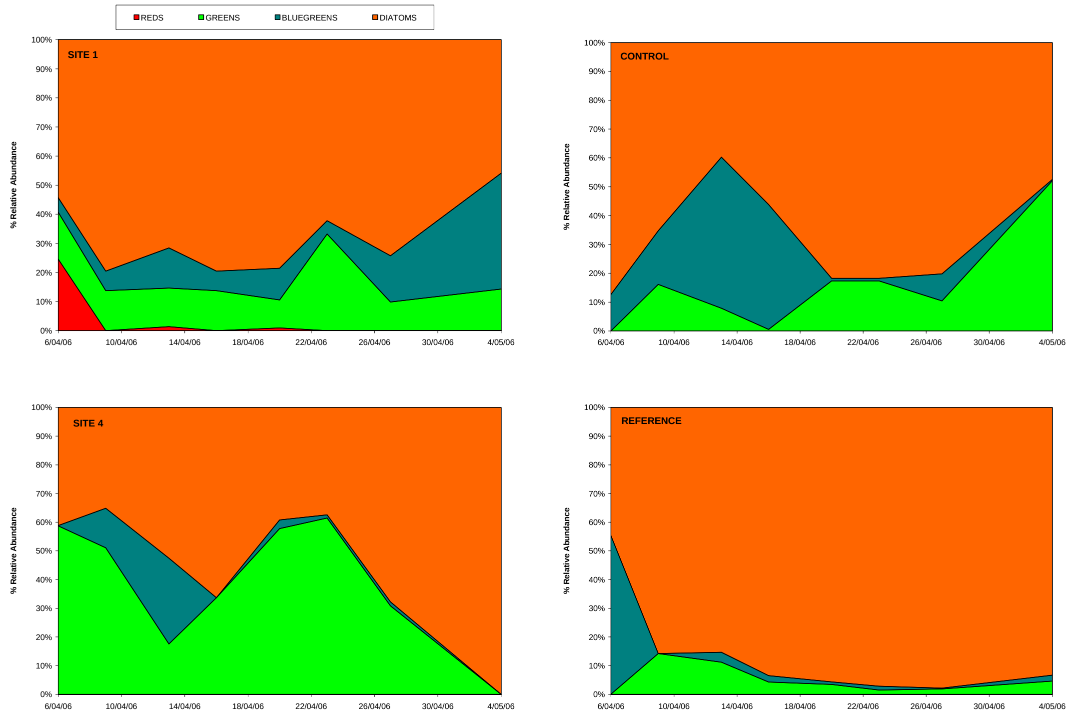

Figure 14: Relative percent abundance (as biovolume) of algal divisions from sites 1 and 4 (Mitta Mitta River) and reference and control sites (n=3).

Summary of biofilm algal species taxonomic composition results

- Algal species richness ranged between 12 and 18 for sites on the Mitta Mitta River, and was consistently lowest at the control reach that did not receive variable flows. Snowy Creek (reference) had a taxa range from 3 to 12, reflecting the disturbance due to high flows early in the study.
- Diatoms formed > 40% of the relative abundance of the biofilm communities at all sites, and over 80% of relative biomass at the reference site, for the duration of the study.
- The 900 ML/day peak cycles reduced the filamentous green algae at Site 1 from approximately 35 to 15% following the 900 ML/day release, but increased the relative biovolume of filamentous Cyanobacteria suggesting these taxa can tolerate higher velocities.
- The relative biovolume of filamentous green algae at Site 4 was reduced from 50-60% to less than 1% after the two 900ML/day peak flow release patterns.

6 Conclusions

Water quality was good at all sites on all sample dates. Total suspended solids and turbidity levels in the Mitta Mitta were generally low for this type of river, even during the peak flows.

The 200-400ML/day cycles did not reduce the total biomass of biofilms on cobble or artificial substrates. The repeated cycling from 200-400ML/day may be encouraging growth of some filamentous taxa (eg. filamentous diatoms) that appear to be tolerant to that range of discharge and are capable of growing fast.

The results of the algal biomass and taxonomic composition of biofilms on cobbles suggests that water velocities of more than 1m/sec that were achieved during the 300-900ML/day cycles were capable of scouring some of the persistent forms of algae that appear to grow readily in the 200-400 ML/day cycle. For example, the relative biovolume of filamentous green algae was reduced from 50-60% to less than 1% at site 4 after the two 300-900ML/day peak flow release patterns.

The artificial substrate experiment confirmed that biofilm biomass can increase over a period of at least 28 days and that a discharge of 900ML/day at Colemans gauge can reduce algal biomass.

7 Flow Management Recommendations

There are two main reasons why it may be desirable to manage the discharge patterns from Dartmouth dams to scour biofilms in the mitta Mitta river. One is to reduce the nuisance factor when biofilm growing on the beds of rivers builds to levels that are unacceptable to the general public or landholders. Quinn (1991) recommended that "to protect contact recreational areas the seasonal maximum cover of stream or river bed by periphyton as filamentous growths or mats (greater than about 3m thick) should not exceed 40% and /or biomass not exceed 100mg Chlorophyll *a* /m^2". Secondly, scouring of biofilms from increased velocity is known to promote early successional algal taxa and result in a biofilm that has a higher diversity. Biofilms are central to important nutrient and biogeochemical processes and are a major food resource for higher organisms including crustaceans, insects and some fish. A high diversity of biofilms usually indicates good ecosystem health.

The following flow management recommendations are based on data collected during April 2006 and may not be appropriate for planning CRP's during periods of low flows in the warmer months.

Recommendation 1:
Constant flows of any velocity will promote the growth of taxa that are tolerant to that velocity. This can reduce the diversity of the biofilm and has the potential to increase the biomass of some taxa to nuisance levels. In this study the 200-400ML/day CRP did not increase the water velocity to a high enough level to scour biofilms from the cobble or artificial substrates and may have encouraged the growth of some filamentous taxa that are tolerant of that range of discharge. Thus, the 200-400ML/day CRP appeared to effectively function like a constant flow regime.

Recommendation 1: If the aim of the CRP's is to reduce total biofilm biomass, discontinuing the 200-400ML/day CRP is recommended. This regime did not decrease total biofilm biomass on cobble or artificial substrates and promoted the growth of taxa that are tolerant to that range in velocities.

Recommendation 2:
If the management objective of the CRP's is to scour biofilms and reduce some of the biomass that has built up on cobbles then one option is to alter the water velocity so that the taxa that have colonised and grown on cobbles will not be able to tolerate the change in discharge. The peak discharge of the CRP would need to be large enough for the biofilm to respond. In this study a peak discharge of 900ML/day and water velocity more than 1m/sec was capable of scouring some of the persistent taxa and produced a change in taxonomic composition of the biofilm.

Recommendation 2: If the aim of the CRP's is to reduce total biofilm biomass, introducing a CRP that has a wider range of discharge (eg. 200 to at least 900ML/day) is recommended. This will disadvantage the 200 ML/day tolerant taxa and have sufficient velocity to relocate the sloughed biofilm downstream. A higher peak velocity also has the potential to scour silt from cobble beds.

Recommendation 3:
If a management objective of the CRP's is to promote a biofilm that has a high diversity then it will be necessary to decrease the frequency of the CRP's so that there is sufficient time between cycles to allow colonisation and growth of different taxa. The artificial substrate experiment demonstrated that there was only a small increase in biofilm biomass on the artificial substrates after 7 days of inundation. Therefore, it is unlikely that maximum biofilm biodiversity can be achieved if the frequency of CRP's is once per week.

If one of the management objectives is to scour biofilm biomass so that it does not build up to a level that is perceived to be a nuisance by the community then the results also support decreasing the frequency of the CRP's. The results of the artificial substrate experiment indicate that under the environmental conditions of this study there was insufficient time for the biofilm total biomass to increase to a nuisance level over a period of one week. Thus, it was not necessary to release a CRP on a weekly basis to scour the biofilm. The artificial substrate experiment demonstrated that biofilm total biomass continued to increase over a period of at least 14 days. So it would be beneficial to introduce a regime with the frequency of the peak discharge being more than 14 days.

Recommendation 3: If the aim of the CRP's is to promote a diverse biofilm and/or scour nuisance biofilm biomass, a cyclic release pattern where peak flows are separated by a period of at least 14 days is recommended. Decreasing the frequency of CRP's will provide sufficient time between cycles to allow colonisation and growth of different taxa.

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APPENDIX 1 – MEDIA RELEASE

Low flow trials in the Mitta Mitta River – information for the community

Did you know that fluctuating river levels can be good for the water quality and environmental health of rivers? Please read on to discover more about flow variability trials being carried out in your local area.

What's the issue?

The Mitta Mitta River receives a minimum 'riparian' release from Dartmouth Reservoir of 200 ML/d (as measured at Colemans gauge) during times when the transfer of larger volumes of water to Hume Reservoir is not required for the operation of the whole River Murray system. The riparian release may be increased from 200 ML/day up to a maximum of 500 ML/d as measured at Colemans (depending on the amount of water in storage in Dartmouth Reservoir) if there is a 'water quality' requirement in the Mitta Mitta River.

Since February 2006, the riparian release from Dartmouth Reservoir has been 300 ML/d. However, it hasn't been provided as a constant release. Rather, the release has been varied on a weekly cycle between 200 and 400 ML/d (averaging 300 ML/d) on a trial basis. The variable release was intended to assist in improving water quality in the Mitta Mitta River during a prolonged period of dry conditions (this is shown as 'Type A' flow variation in **Figure A**). This flow pattern also received general support from landholders as the increased river levels over weekends has improved pumping ability.

Discussions with environmental expert Dr Robyn Watts and her team from Charles Sturt University and the University of New England led to the development of an alternate variable release pattern for consideration by River Murray Water. The recommended release pattern is shown as 'Type B' flow variation in **Figure A**. To achieve this flow pattern a higher release averaging 400 ML/d (rather than 300 ML/d) as measured at Colemans is required, which allows a greater range of flow variation from 300 ML/d to 900 ML/d (rather than 200 ML/d to 400 ML/d) on a weekly cycle.

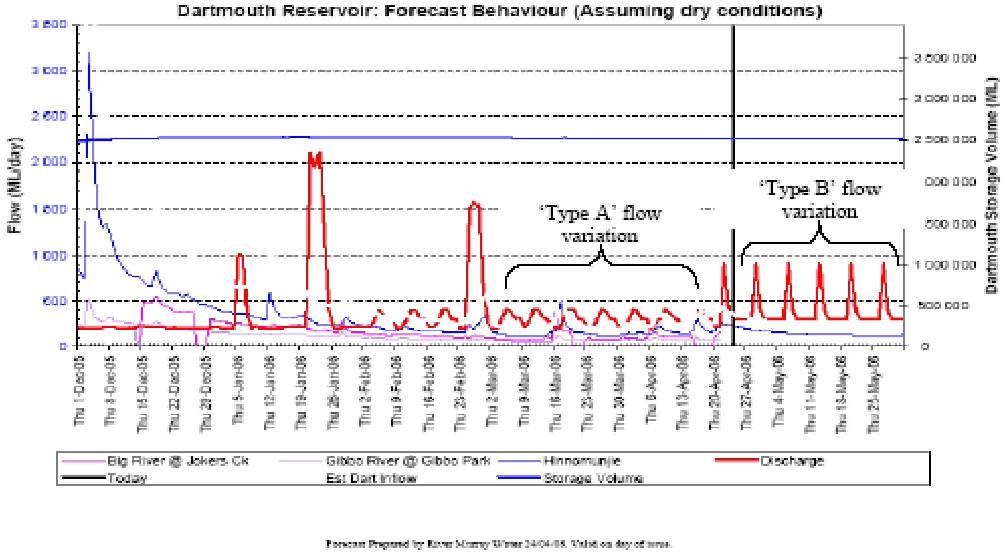

Figure A. Plot showing flow at Colemans (red line) during the variable low flow release trial.

River Murray Water approved the higher release (which commenced on 21 April) on a trial basis. Current conditions provided a good opportunity to conduct the trial as there is a high chance of high water transfers from Dartmouth to Hume Reservoirs being required over the coming 2006/07 season. Also, there is a low risk that the transferred water will subsequently spill from Hume Reservoir as a result of the trial.

A monitoring project (funded under the Murray-Darling Basin Commission's 'Living Murray' initiative) has been initiated to examine water quality and environmental health indicators in relation to the low flow variable release trails during April 2006 (**Figure B**).

Figure B. Testing water quality in the Mitta Mitta River at Tallandoon when the flow was about 480 ML/d.

So, what do we think this new flow pattern will achieve?

During prolonged periods of relatively constant flow (particularly at low flows in the warmer months) people have often observed the rapid growth and accumulation of long strands of slippery, filamentous green algae clinging to rocks and woody debris in the river. Scientists call this 'biofilm'. A 'healthy' biofilm contains diverse types of algae, fungi and other microscopic organisms. In contrast, an 'unhealthy' biofilm consists almost entirely of green filamentous algae as shown in **Figure C**. From previous studies in the Mitta Mitta and other rivers it has been shown that the biofilm can become unhealthy when the flow is constant for long periods of time, among other contributing factors such as nutrient levels. Under these conditions the green filamentous algae can become dominant, at the expense of other types of algae found in healthier and more diverse biofilms.

Figure C. The cyclic flow pattern being trialled is intended to scour the biofilm from the river bed cobbles so that there is not a uniform cover of filamentous green algae as shown in these photos of the Mitta Mitta River downstream of Dartmouth Dam. (Close up view on the right).

Why study biofilms?

Well, being at the bottom of the food chain, biofilms are like a 'smorgasbord' of food for a variety of river biota including fish. A more diverse biofilm provides a wider range of food sources for the riverine community. Biofilms are known to respond rapidly (i.e. within days) to changes in the flow, that's why they have been selected to be monitored. They tell us a great deal about the water quality and more generally about the health of the river.

The expected outcome of the variable low flow trials in the Mitta Mitta River is that cycling the release from 300 Ml/d to 900 ML/d will result in higher water velocities that will scour the filamentous biofilms clinging to the rocks and woody debris. By scouring the biofilm (that is, removing and washing it away), it encourages new and better growth of a range of species that make up the biofilm. Previous studies (at higher flow rates) in the Mitta Mitta River have shown that when the flows are cycled like this the quality of the biofilm starts to become more like that in nearby unregulated and healthy waterways such as Snowy Creek.

A potential issue associated with the trial over coming weeks is an initial increase in the suspended material in the water column on the peak of the cycle (over weekends) which may interfere with filters on pumping equipment. This aspect is expected to diminish in significance after the first scouring event. River users have been advised by River Murray Water to take this into account when planning their activities.

Your feedback

River Murray Water and Goulburn-Murray Water are keen to receive feedback (on both positive and negative aspects) of the trial from the local community, so that a range of information can be taken into consideration to guide future release patterns. A report on the environmental monitoring will be available by around mid 2006 and can be obtained by contacting River Murray Water.

For more information please contact: River Murray Water:
Email: rmwoperator@mdbc.gov.au or Phone: 02 6279 0168.

APPENDIX 2 – ALGAL SPECIES LIST

Species list of algal taxa found in the Mitta Mitta and Buffalo Rivers, and Snowy Creek

Taxa	SITE 1	SITE 4	REFERENCE	CONTROL
RHODOPHYTA				
Batrachospermum sp	*			
CHLOROPHYTA				
Akinstrodesmus sp		*	*	*
Closterium sp	*	*	*	*
Cosmarium sp	*	*	*	*
Drapnaldia (large cell)	*	*	*	
Drapnaldia (small cell l)	*	*	*	
Oedogonium sp	*	*	*	
Pediastrum sp		*		*
Scenedesmus quadricauda	*	*	*	
Spirogyra sp		*		*
Stigeoclonium sp	*	*	*	*
CYANOPHYTA				
Anabaena sp	*		*	
Gleotrichia sp	*	*	*	*
Leptolyngbya sp	*	*	*	*
Lyngbya sp	*		*	*
Oscillatoria sp	*	*	*	*
Planktolyngbya sp 1	*			*
Planktothrix sp1t	*			
Planktothrix sp2			*	
Plectonema sp		*		
Pseudoanabaena sp	*	*	*	*
BACILLARIOPHYTA				
Achnanthes cf.subexigua	*	*	*	*
Achnanthes exigua	*	*		
Achnanthes sp1	*	*	*	
Achnanthidium minutissima	*	*	*	*
Amphora veneta		*		
Aulocoseira granulata	*	*		*
Cocconeis sp 1	*	*	*	
Craticula sp1	*			*
Ctenophora sp1			*	

Cyclotella sp1	*	*		*
Cymbella cistula	*	*	*	*
Cymbella tumidia	*	*	*	*
Encynema gracilis	*	*	*	*
Encynema silesiacum	*	*	*	*
Encynonopsis sp1	*	*	*	*
Fragillaria capucina	*	*	*	*
Fragillaria sp1	*	*	*	*
Fragillaria sp2 (large)	*	*	*	*
Fragillarioforma virescens		*		
Frustulia rhomboides	*	*	*	*
Gomphonema acuminatium	*			*
Gomphonema clavatum		*	*	*
Gomphonema lagenula	*	*	*	
Gomphonema parvulum	*	*	*	*
Gomphonema pseudoaugar		*	*	*
Gomphonema truncatum	*	*	*	*
Gyrosigma sp1	*	*		*
Melosira varians	*	*	*	*
Navicula erifuga	*			
Navicula gregaria	*	*	*	*
Navicula pusilla			*	
Navicula radiosa	*	*	*	*
Navicula schroeteni	*	*	*	*
Navicula sp1	*			
Nitzschia gracilis	*	*	*	*
Nitzschia sp1	*	*	*	*
Pinnularia subcapitata		*	*	
Surrirella sp1	*	*		*
Tabellaria flocculosa	*		*	*
Tryblionella apiculata		*		