

INTERIM REPORT #1- May 2004

School of Chemistry, Monash University

Title: Effect of Bushfires on Receiving Waters, Eastern Victoria.

Masters Student: Sarah Jane Alexander

Supervisors: Dr Mike Grace
Assoc. Prof. Ian McKelvie

Funding: Department of Sustainability and Environment (DSE)

1. Introduction:

The 2003 Alpine fires burnt over one million hectares in eastern Victoria, including parts of the Tambo River and Dartmouth Reservoir catchments. Changes to the hydrology of streams caused by bushfires have been widely studied [1-5] however little is known about the effects of fires on standing water-bodies such as lakes, reservoirs and estuaries. This research project aims to question and further develop the understanding of how bushfire contaminants affect water-bodies. By undertaking a study that fulfils the research questions outlined, management plans; modeling and guidelines in relation to bushfire-affected water-bodies can be further developed and effectively enhanced.

The following key research questions will be examined:

- What increases in nutrient concentration occur, as a result of the fires, within Dartmouth Reservoir and along the length of the Tambo River? Nutrient load calculations will be made based on flow gauging stations at Mitta Mitta River at Hinnomunjie Bridge and the Tambo River at Swifts Creek. Load calculations are contingent on the continued deployment of autosamplers post March 2004.
- What impact does the delivery of high nutrient and sediment loads from the bushfire areas have on the large receiving water bodies? In-reservoir nutrient processing will be examined during this project to determine these impacts.¹
- Does the delivery of nutrient and sediment affect the likelihood of algal bloom development in both the short (1-2 year) and longer term (5+ years)? Preliminary modelling will be undertaken during the course of the project and in addition, care will be taken to ensure that data collected in this work will be suitable to

¹ In-stream processing will *not* be examined here as this means resolving spatial and temporal changes in nutrient concentrations along the stream length – literally by following a single parcel of water down the river and accounting for all tributary influences as well - this is a very major undertaking (a Masters or PhD project in it's own right) and is inconsistent with the focus on the receiving waters in this work.

drive existing models (e.g. CSIRO's Gippsland Lakes Model). Depending on project progress, the algal model developed by Webb, Grace & Linacre (Water Studies Centre, Monash University) may be used to test future scenarios involving different sediment and nutrient delivery to the receiving waters.

- Will there be water quality deterioration in these water-bodies due to increased turbidity?
- Will respiration in receiving waters be enhanced by bushfire-related detritus, thereby causing anoxia and potential nutrient and toxicant release? This will be undertaken largely in Dartmouth Reservoir but will also include the salt wedge region of the Tambo River, provided that the detritus has reached that far downstream within the timeframe of the project.

The study will focus upon Dartmouth Reservoir and the entire length of the Tambo River including the estuarine mouth. The headwaters of the streams and rivers, which feed into Dartmouth Reservoir, and the Tambo River were severely burnt. Both water bodies have very different physical and chemical characteristics. For example Dartmouth is an artificial deep freshwater system while the Tambo River is an important tributary of the shallow, tidal Gippsland Lakes system. The response to the high input of nutrients and sediments delivered into each system is likely to differ substantially due to these fundamental chemical and physical variations.

Dartmouth Reservoir, located 300 km northeast of Melbourne, is managed by Goulburn Murray Water for the Murray Darling Basin Commission and is Victoria's largest capacity dam holding 4 million ML when full (38% capacity as of 11/9/03). Dartmouth's catchment is 3 611 square kilometres and during the 2003 bushfire, 95% of the catchment was burnt.

The other study area is the Tambo River, which is a key tributary of the Gippsland Lakes. The Gippsland Lakes are located 340km from Melbourne and consist of a group of coastal lakes isolated from Bass Strait by the 90-mile beach. The Tambo contributes 11% of the total annual inflows for the Gippsland Lakes and drains into Lake King. The headwaters were burnt, as were 35km from the headwaters to Swifts Creek. The river flows from Swifts Creek toward the Gippsland Lakes passing through floodplains, grazing pastures, bushland and coastal heath.

i) Dartmouth

Dartmouth is a deep (up to 140m) fresh water meromictic system. The monimolimnion is not thermally stratified whilst the mixolimnion mixes once a year (see Figure 2.1.1), during the winter months. During the summer months the mixolimnion is distinctively thermally stratified. The surface temperatures can be in excess of 20 degrees- this is particularly important, as algae production will be optimized at these temperatures. A distinct anoxic layer has been identified in the depths of the reservoir - from around 55m (see Figure 2). The two distinct arms of Dartmouth are formed from two rivers: the Mitta Mitta River to the west and the Dart River to the East. Unlike the deeper section of the reservoir near the dam wall, the Mitta Mitta Arm and Dart Arm sites do not have a permanent anoxic layer and are only around 50m deep.

The top layer of the reservoir has fairly consistent dissolved oxygen concentrations with the top 20m being above 75% saturation, which is vital for biota such as fish.

ii) Tambo River

The mouth of the Tambo River is a tidal estuarine system with a salt wedge that extends 3km up the river from Lake King. Salinity is of particular interest, as it will significantly affect the settling rate of suspended sediments. The mouth of the river would be a likely source of aggregation for the bushfire sediments and ash. With carbon particles detected in sediment samples taken at the River's mouth, see results and discussion for further detail, this appears to be the case. Additional study sites were included along the length of the Tambo so that downstream progress of sediment and ash could be assessed.

1.1 Sampling Sites:

Both studies areas have included upstream and/or tributary rivers for sampling as well as the receiving waters. There are six study sites selected for the Dartmouth system which include:

Three reservoir sites selected:

- Mitta Mitta River Arm
- Dart River Arm
- Limnology Site (Near the Dam Wall)

Three river sites were also included:

- Big River at Joker Creek (Site # 401216)
- Mitta Mitta River at Hinnomunjie Bridge (Site # 401203)
- Dart River at Entrance to Dartmouth Reservoir

5 study sites selected for the Tambo system include (see Map 2):

- Tambo River at Smiths Creek (Head Waters) (Site # 223214)
- Tambo River at Swifts Creek (Site # 223202)
- Tambo River at Ramrod Creek (Site # 223205)
- Morass Creek
- Tambo River at Johnsonville (Mouth)

1.2 Interim Report #1

The following report incorporates the preliminary results obtained during a testing period spanning from July 2003 to January 2004. Data can be obtained from Appendices 1-12 for the Dartmouth System and 13-18 for the Tambo System.

2. Results and Discussion

2.1 Dartmouth

During the preliminary study period the temperature profile of Dartmouth Reservoir at the Limnology site was as seen in previous years. That is a monimolimnion that is not thermally stratified whilst the mixolimnion mixed once a year, during the winter months (Figure 2.1.1). During Jul-03 the Limnology site was not thermally stratified whilst in Nov-03 and Jan-03 there was thermal stratification as expected (Figure 2.1.2).

Prior to the study period the reservoir behaved as a meromictic system in regards to Dissolved Oxygen (DO) with an anoxic layer of water in the depths of the reservoir (Figure 2.1.3). During the study the DO profile did not conform to this classification, apart from in Jul-03. The Sep-03 profile was dramatically different with an oxic (high oxygen) band of water in the depths of the reservoir. This behaviour continued during Nov-03 and Jan-04 where the DO profile was >40% DO throughout the water column.

The Dart Arm DO profile was stratified from Jul-03 till Oct-03. Nov-03 and Jan-04 profiles show that the Dart Arm was not stratified and had a DO of 40% saturation in the bottom layer. The Mitta Arm (Figure 2.1.4) showed a band of oxic water at the bottom of the water column in both Jul-03 and Sep-03. It is not yet known if this is typical behaviour at these sites as testing started in Jul-03 and no previous measurements have been made.

The DO stratification of the reservoir is of particular importance, as it will influence the release of phosphorus from the sediments, with anoxic conditions found to increase phosphorus release from sediment (6).

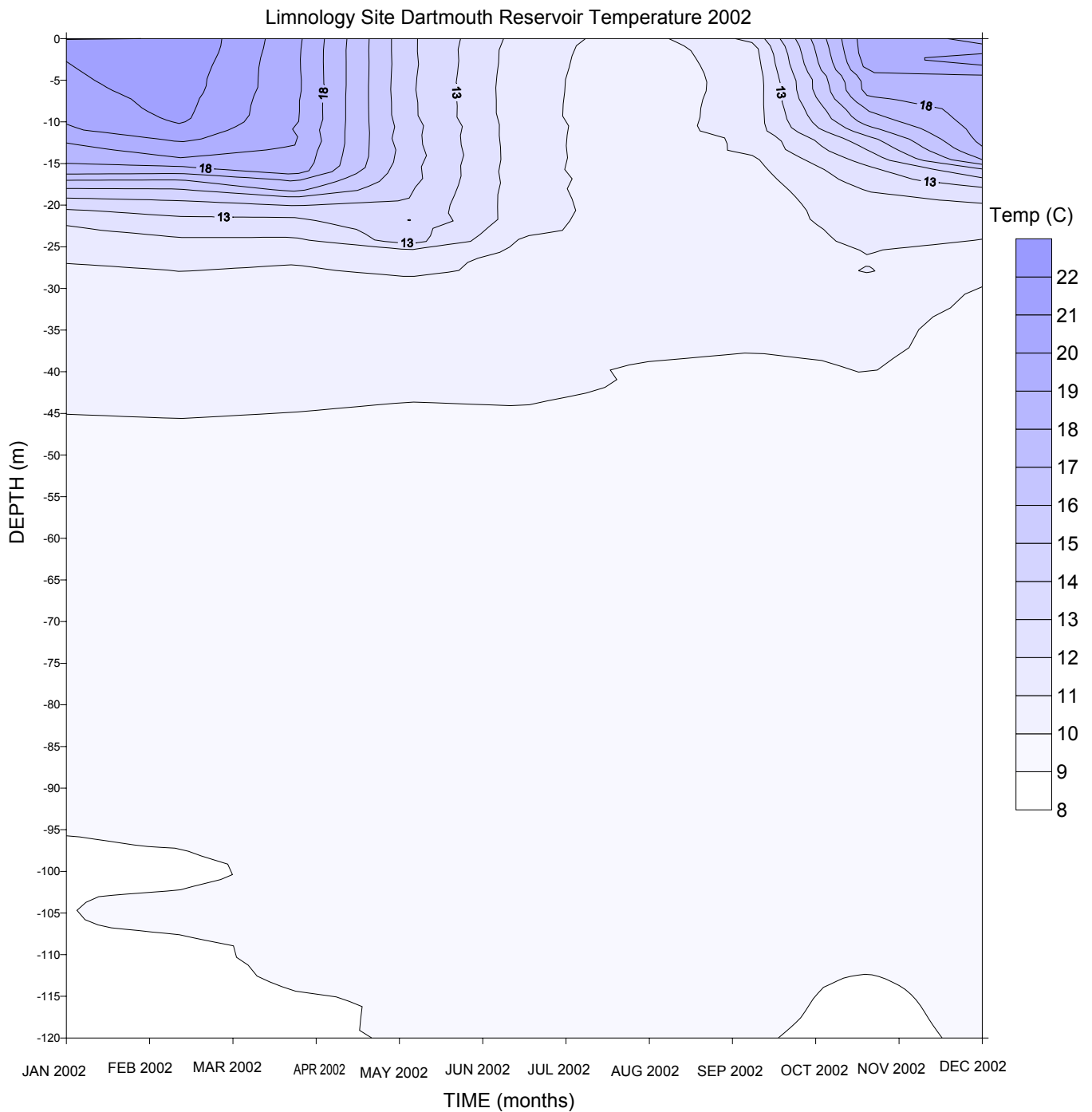


Figure 2.1.1 -Isopleths of Temperature (degree) for Dartmouth Reservoir Limnology Site 2002²

Dartmouth Reservoir Limnology Site Dissolved Oxygen and Temperature Profiles

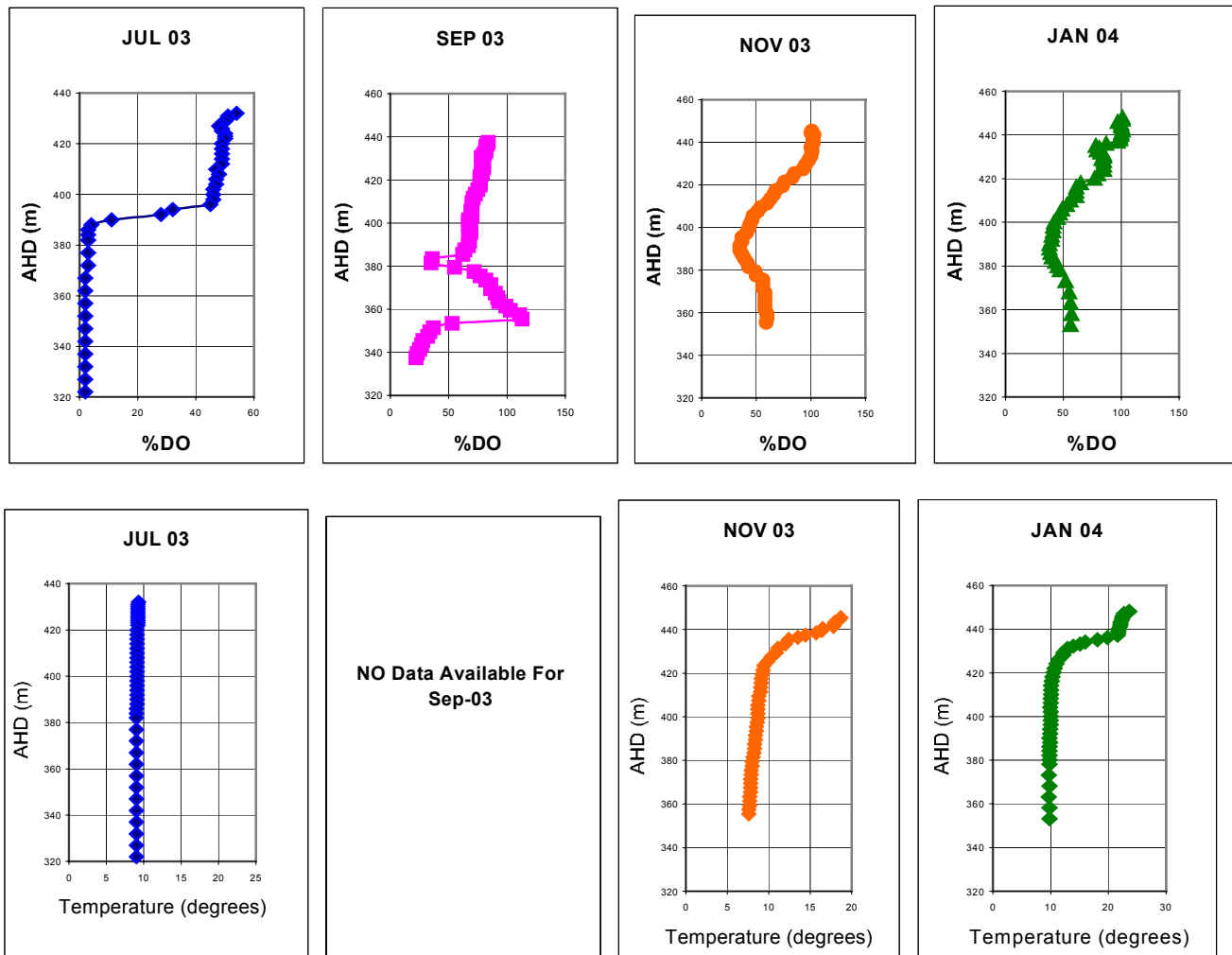


Figure 2.1.2 -Dissolved Oxygen (%Sat) and Temperature (degrees) profiles Dartmouth Reservoir Limnology Site

² Data From Goulburn-Murray Water

Limnology Site Dartmouth Reservoir Dissolved Oxygen (DO) 2002

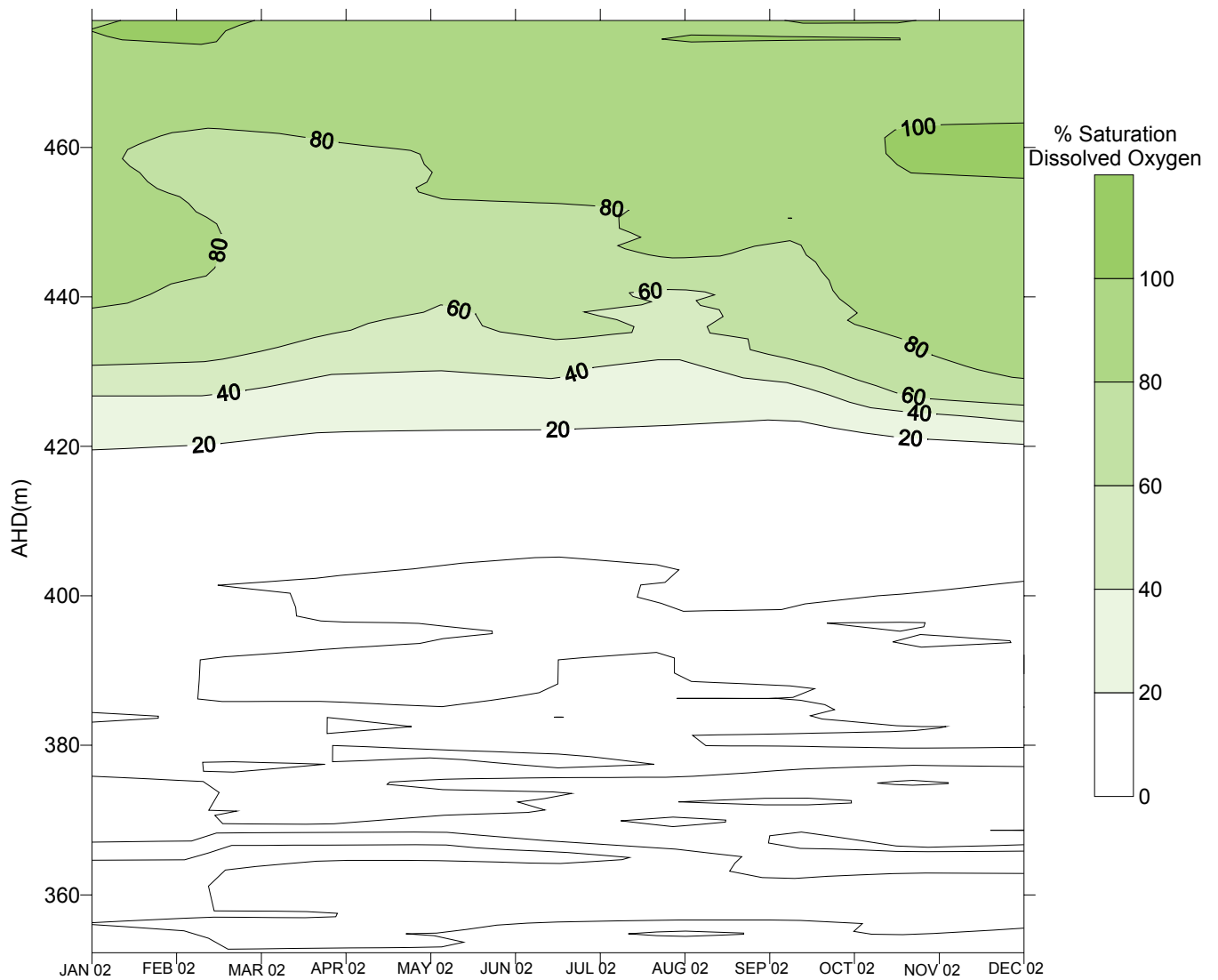


Figure 2.1.3 -Isopleths of Dissolved Oxygen(%sat) for Dartmouth Reservoir Limnology Site 2002³

³ Data From Goulburn-Murray Water

Dartmouth Reservoir Mitta Mitta Arm Dissolved Oxygen Profiles

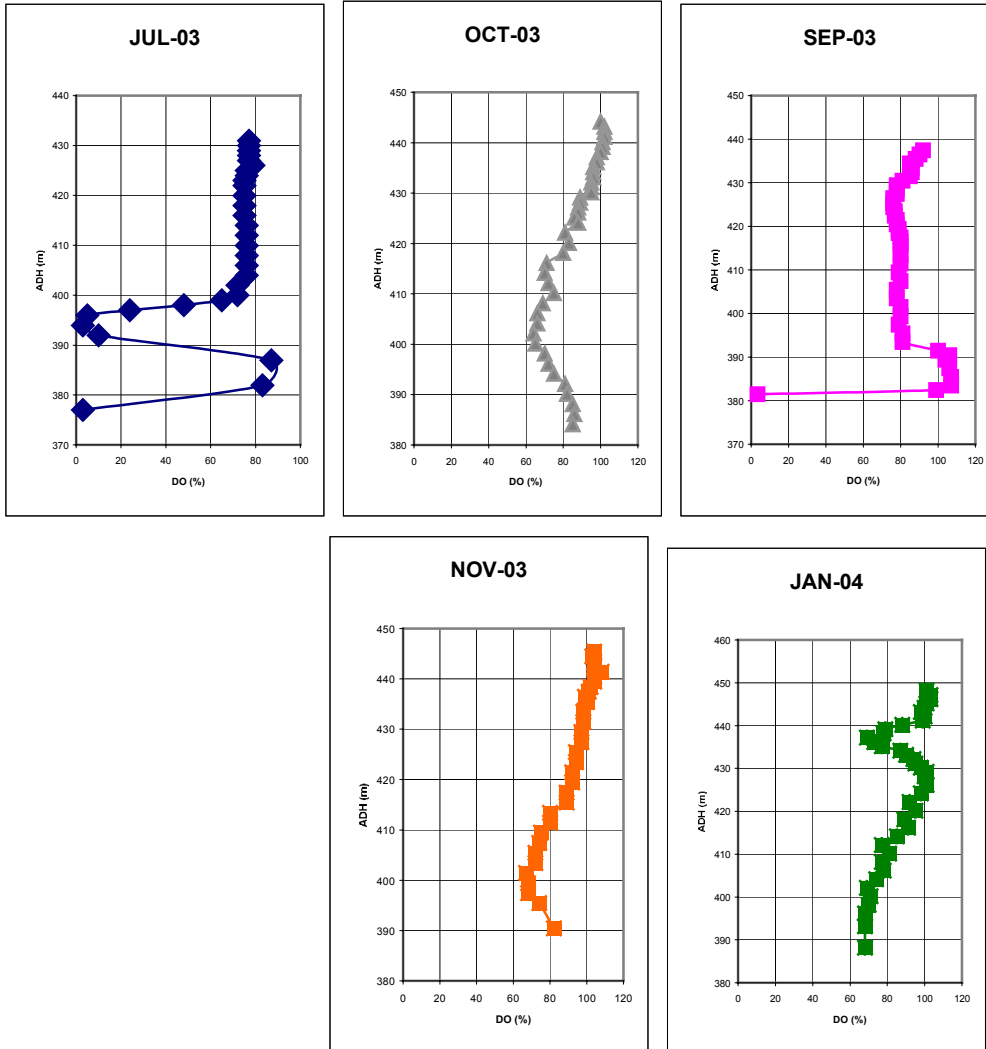


Figure 2.1.4- Dissolved Oxygen (%sat) profiles Dartmouth Reservoir Mitta Mitta Arm

2.1.1 What increases in nutrient concentration occur, as a result of the fires, within Dartmouth Reservoir?

High concentrations of nutrients within the Dartmouth tributaries were seen during the preliminary study period for both grab samples and autosamplers. River flow data, as Discharge, is only available for days when grab samples are made by www.vicwaterdata.net contractors thus exact pre-fire comparisons can no be made with sample collected by the Water Studies Centre.

Total Nitrogen (TN) concentrations steadily decreased for all the tributary sites during the preliminary study period. Concentrations of 9.02mg/L of TN at the Hinnomunjie site were recorded in Jul-03 which when compared with Jul-02 (discharge is not necessarily comparable) the TN (TKN + NO_x) concentrations of 0.07mg/L loosely represents a 100-fold increase.

Nitrite/ Nitrate (NO_x) concentrations also mimicked the trend seen for TN and steadily decreased at all sites during the study period.

No pre-fire data is available for Ammonia (NH₄⁺) concentrations in the Dartmouth tributaries. NH₄⁺ has changed in concentration during the study post fire. 39µg/L of NH₄⁺ was measured in the Dart River during Jul-03 in comparison to Jan-04 where the concentration of NH₄⁺ was 9µg/L. It will become clearer as the project progresses as to if these changes are 'common' seasonal trends or the result of the bushfires.

The average Total Phosphorus (TP) concentrations recorded at the Hinnomunjie site during the study period was 700µg/L compared with 2002 when the TP average was 22µg/L. This indicates that there was an increase although flow conditions cannot be taken into account thus the magnitude of increase cannot be fully determined.

Filterable Reactive Phosphorus (FRP) also appeared to increase, as the average FRP in 2002 was below detection limits (0µg/L) compared with an average of 14µg/L at the Hinnomunjie site during the study period.

An increase in nutrient concentration when taking the river's flow (or discharge) into account does appear to have occurred post bushfire. Data obtained from www.vicwaterdata.net indicates this (Figures 2.1.5 & 2.1.6). For example: in Apr-03 with a discharge of 138ML/Day and a TP concentration of 300µg/L, NO_x concentration of 300µg/L and FRP concentration of 250µg/L compared with Mar-02, a pre-fire month, which had a discharge of 220ML/Day and TP concentration of 20µg/L, NO_x concentration of 10µg/L and FRP concentration of 0µg/L. The increase in TP seen represents a 15-fold increase.

The autosampler at the Hinnomunjie site also obtained samples with nutrient concentrations significantly greater than seen during pre-fire years. In particular 2 events, which occurred in Jul-03 and Aug-03, recorded TP concentrations of 8mg/L and TN concentrations of 21mg/L during the peaks captured (Figure 2.1.7). According to Water Quality Guidelines, the trigger value for causing algal problems in Upland Rivers [6] for TP is 0.02mg/L and 0.25mg/L of TN thus the concentrations measured are extremely ecologically significant.

TKN & NOx Jan-02 till Mar-04
Mitta Mitta River Hinnomunjie Bridge

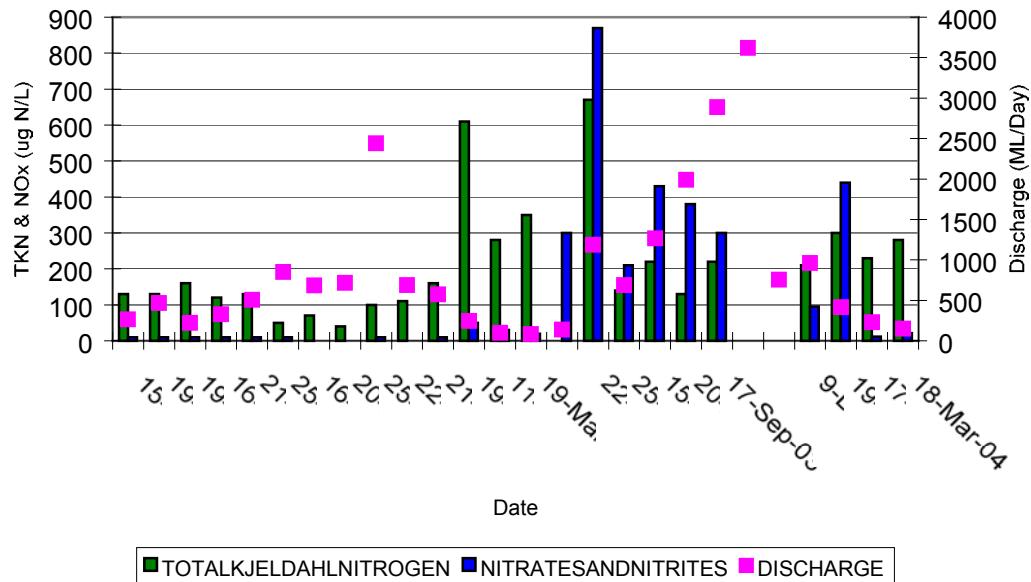


Figure 2.1.5 –Total Kjeldahl Nitrogen & Nitrite/Nitrate Concentrations verse Discharge, Mitta Mitta River Hinnomunjie Bridge⁴

TP & FRP Jan-02 till Mar-04
Mitta Mitta River Hinnomunjie Bridge

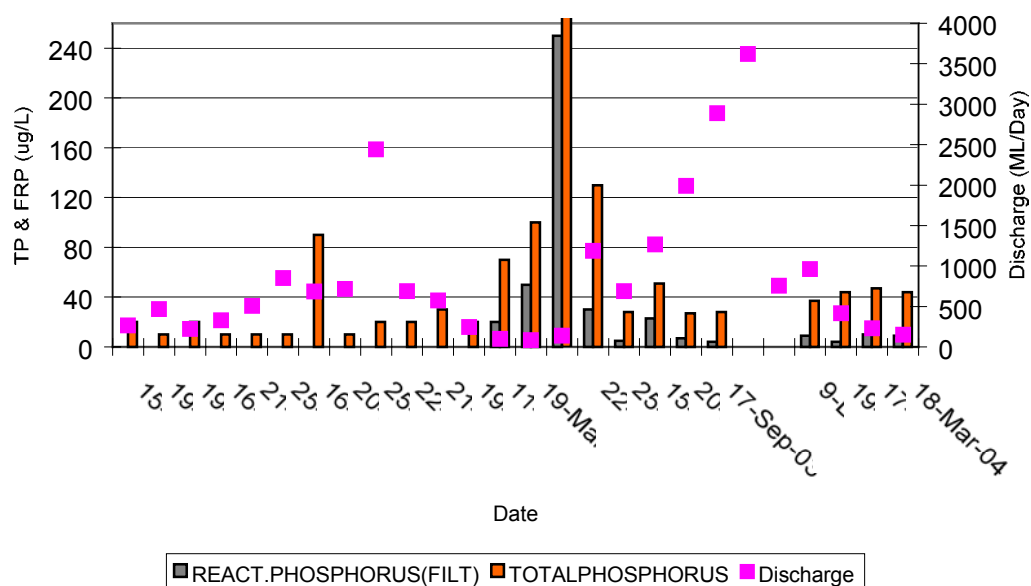


Figure 2.1.6 –Total Phosphorus & Filterable Reactive Phosphorus Concentrations verse Discharge, Mitta Mitta River Hinnomunjie Bridge⁵

⁴ Data from www.vicwaterdata.net

With the tributaries delivering high nutrient waters to the reservoir, one would expect to see an increase in nutrients, however at this preliminary stage the change in nutrient concentrations is not clearly evident. In the Dartmouth Reservoir, at the Limnology Site, there appears to have been a slight increase in the concentration of Nitrogen (Figure 2.1.8). During 2001 the approximate surface measurement of TN (TKN + NO_x) was on average 0.18mg/L⁶ in the surface waters. During the preliminary study period the surface TN average was found to be 0.28mg/L of TN almost a 50% increase. TN appeared to steadily increase with depth during each sampling occasion.

Nitrite/Nitrate (NO_x) and Ammonia (NH₄⁺) trends at the Limnology site (Figure 2.1.9) displayed an inverse pattern to each other. For example in Jul-03 NH₄⁺ increased steadily with depth in comparison to NO_x that decreased with depth. This trend is expected as nitrification (NH₄⁺ to NO_x) decreases in deeper waters with low DO concentrations. This pattern was opposite in the months following Jul-03. High NO_x concentrations deep in the reservoir were detected and potentially due to high NO_x concentrated waters discharging into the reservoir and the presence of DO in the depths of the reservoir (figure 2.1.2). NO_x is likely to remain high in the depths of Dartmouth until the waters become anoxic and enough organic material is available to facilitate denitrification. TN, NH₄⁺ and NO_x patterns and concentrations measured at the Limnology site were also seen at both the Mitta Arm and Dart Arm of the reservoir.

Total Phosphorus (TP) concentrations (Figure 2.1.10) at the Limnology site remained at <20µg/l within the top 40m of the water column during the preliminary study period. There was an increase in TP detected in the surface waters for the initial months tested, which then disappeared by Nov-03 as concentrations of TP were similar to pre-fire concentrations. For example in the pre-fire year 2001, TP concentrations in the surface waters at the Limnology site averaged 7µg/L⁷. In comparison Sep-03, concentrations of TP were 19µg/L and by Nov-03 concentrations were 5µg/L of TP. TP generally increased down through the water column. TP concentrations at Mitta Arm and Dart Arm showed very similar trends. Interestingly for both the Mitta Arm and Dart Arm a band of water during Jul-03 was found to contain 40µg/L of TP. This band of water would be consistent with the level at which the Mitta Mitta River and Dart River would enter the reservoir at that time of the year⁸.

There was no detectable change in Filterable Reactive Phosphorus (FRP) within the surface waters at the Limnology site. Pre fire values, 2001, of FRP averaged 3µg/L of FRP; similar concentrations were detected from Jul-03 until Jan-04 (Figure 2.1.11). FRP tended to increase in concentration down through the water column. Concentrations in excess of 10µg/L FRP at Mitta Arm and Dart Arm were recorded in Sep-03 and were located at the same depth as the high TP band. FRP is of particular interest since it conventionally equates to the most bioavailable fraction of the TP pool.

⁵ Data from www.vicwaterdata.net

⁶ Data provided by Goulburn-Murray Water

⁷ Data obtained from Goulburn-Murray Water

⁸ Reference: P.Liepkalns: Goulburn-Murray Water

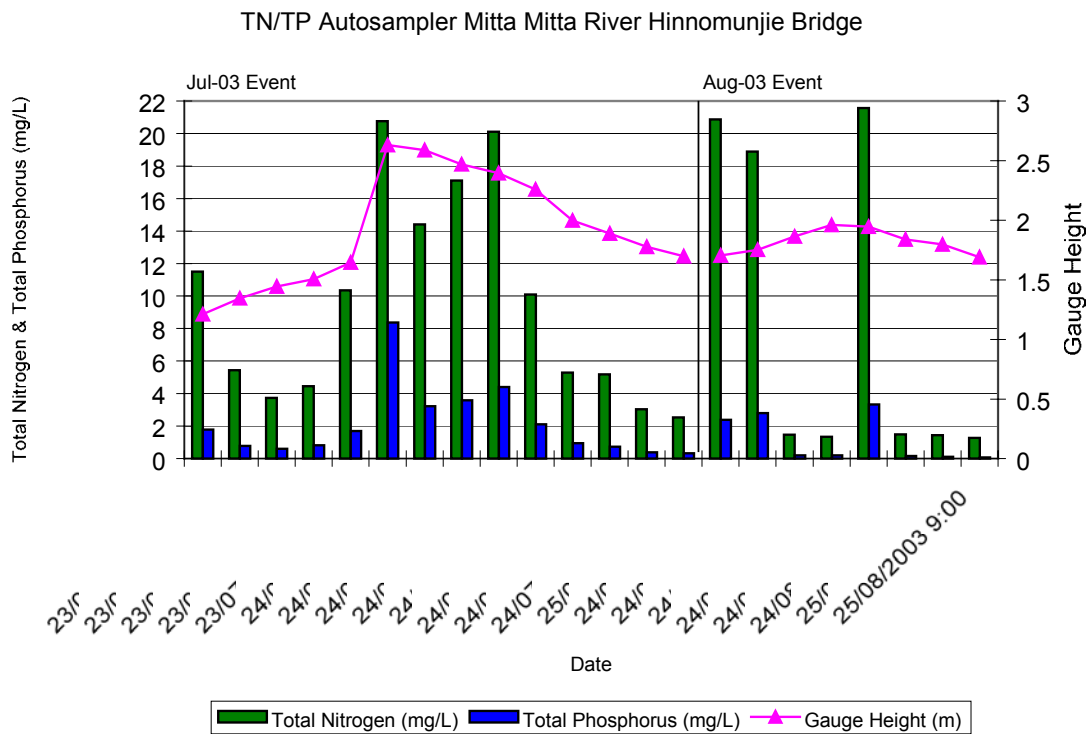


Figure 2.1.3 –Total Phosphorus & Total Nitrogen Concentrations captured via autosampler, Mitta Mitta River Hinnomunjie Bridge

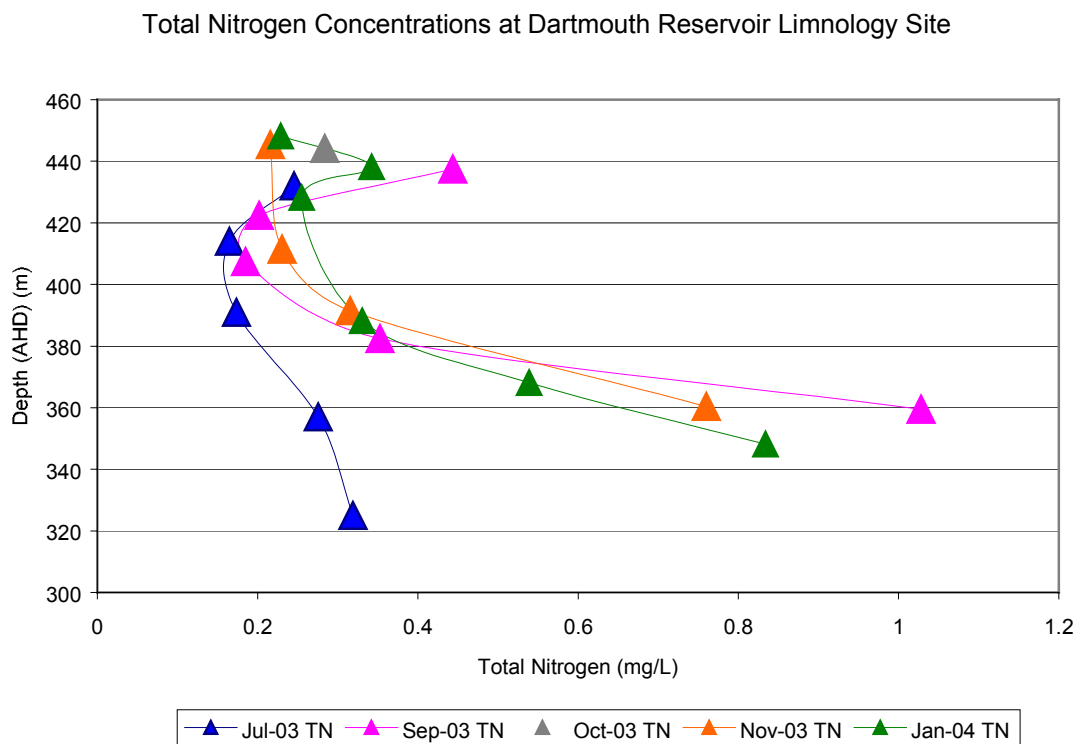


Figure 2.1.4-Total Nitrogen (mg/L) concentrations at Dartmouth Reservoir Limnology

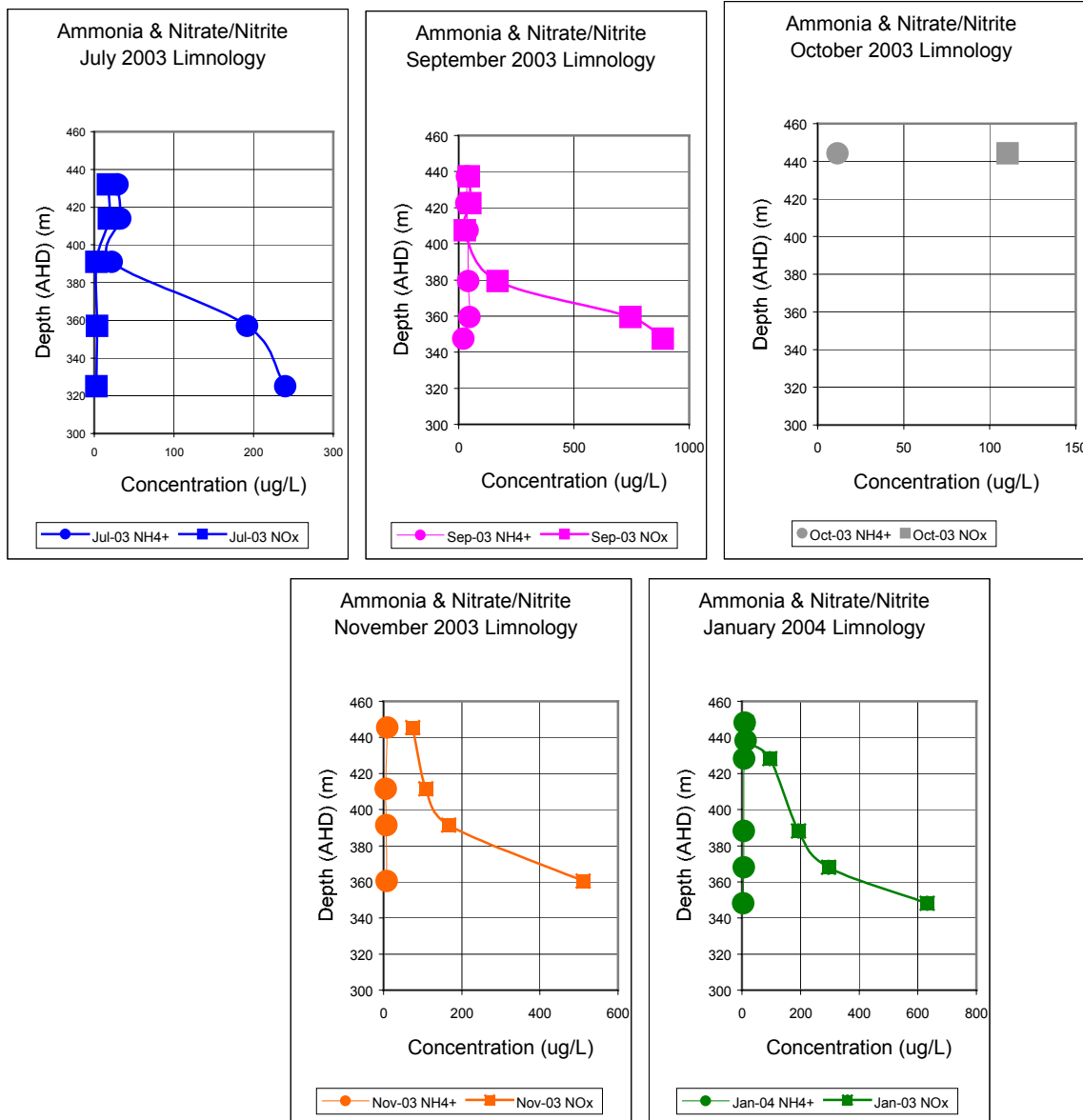


Figure 2.1.9-Ammonia and Nitrite/Nitrate concentrations at Dartmouth Reservoir Limnology

Site

Total Phosphorus Concentration at Dartmouth Reservoir Limnology Site

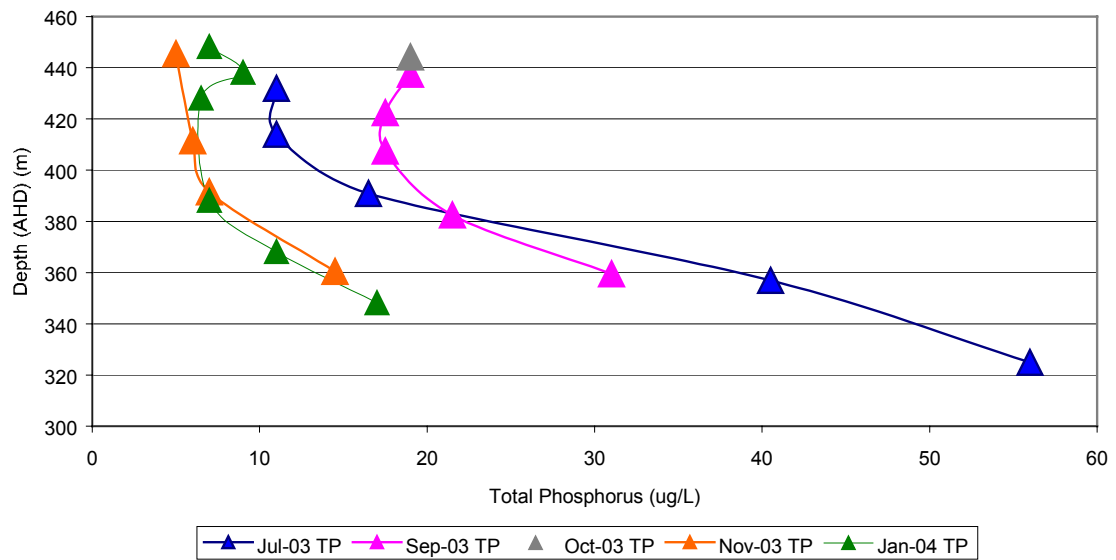


Figure 2.1.10-Total Phosphorus ($\mu\text{g/L}$) concentrations at Dartmouth Reservoir Limnology

Site

Filterable Reactive Phosphorus Concentrations at Dartmouth Reservoir Limnology Site

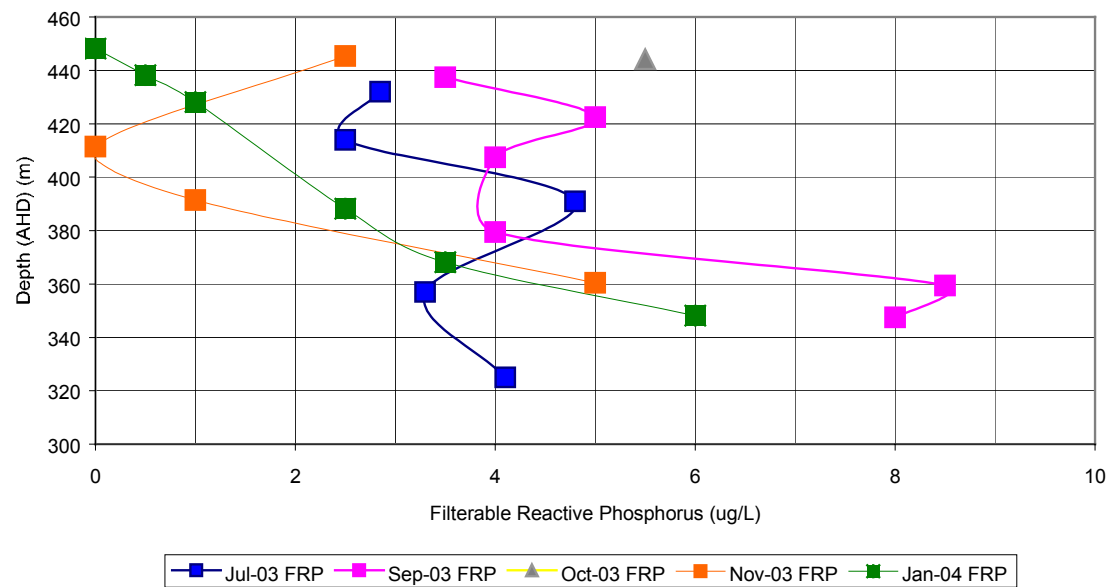


Figure 2.1.11-Filterable Reactive Phosphorus ($\mu\text{g/L}$) concentrations at Dartmouth Reservoir Limnology

Site

2.1.2 What impact does the delivery of high nutrient and sediment loads from the bushfire areas have on Dartmouth Reservoir?

The potential impacts of high nutrient and suspended sediment loads on the Reservoir have yet to be thoroughly investigated. High nutrients (see 2.2.1) and sediment loads have been detected in the Dartmouth's tributary sites. An increase in suspended solid (SS) concentration when taking the river's flow (or discharge) into account does appear to have occurred post bushfire. Data obtained from www.vicwaterdata.net indicates this (Figure 2.1.12). For example: in Apr-03 with a discharge of 138ML/Day the SS was 360mg/L compared with Mar-02, a pre-fire month, which had a discharge of 220ML/Day and a SS concentration of 1mg/L, representing a 360-fold increase. With increased TSS there was also an increase in the Turbidity of the water. For example during May-03 the turbidity was 28 NTU (Discharge: 1188ML/Day, SS: 91mg/L) compared with Nov-01, a prefire year, the turbidity was 2NTU (Discharge: 1139ML/Day, SS 4mg/L).

There was also a TSS of 84mg/L in Jul-03, obtained by SJA, at the Hinnomunjie Site, without being able to take discharge into account this value is still regarded as high when considering that over the past 10 years the highest SS concentration at this site has been 260mg/L when the river was in flood with a discharge of 30900ML/Day which occurred in Sep-98⁹.

At the Limnology site of the reservoir, TSS (Figure 2.1.13) was less than 4.0 mg/L throughout the water column. During Jul-03 and Sep-03 values were marginally higher than seen in Jan-04. Light profiles were only measured in Oct-03 and Jan-04 (Figure 2.1.14), during these two testing months the euphotic depth (>1% light transmitted,) extended down to at least 5 m, this means that over 95% of the water column isn't sufficiently sunlit to permit algae growth. Future consideration will be given to looking at the ratio of euphotic depth to the mixing depth of the surface water, this will determine how long each algae spend in the euphotic zone and therefore whether this period is long enough for substantial growth. The other 2 arms of the Reservoir also displayed similar characteristics regarding TSS and Light Profiles as seen at the Limnology site.

Although high nutrient and sediment are being transported into Dartmouth Reservoir, the impact of this has not yet been detected. Impacts of increased SS and nutrients in the reservoir may include a change in the light profile of the reservoir with increased SS concentrations in the surface waters, which may limit the euphotic zone depth and thus reduce algal populations. If nutrient concentrations in the surface waters were to increase there may be increased primary production within the reservoir.

⁹ Data obtained from www.vicwaterdata.net

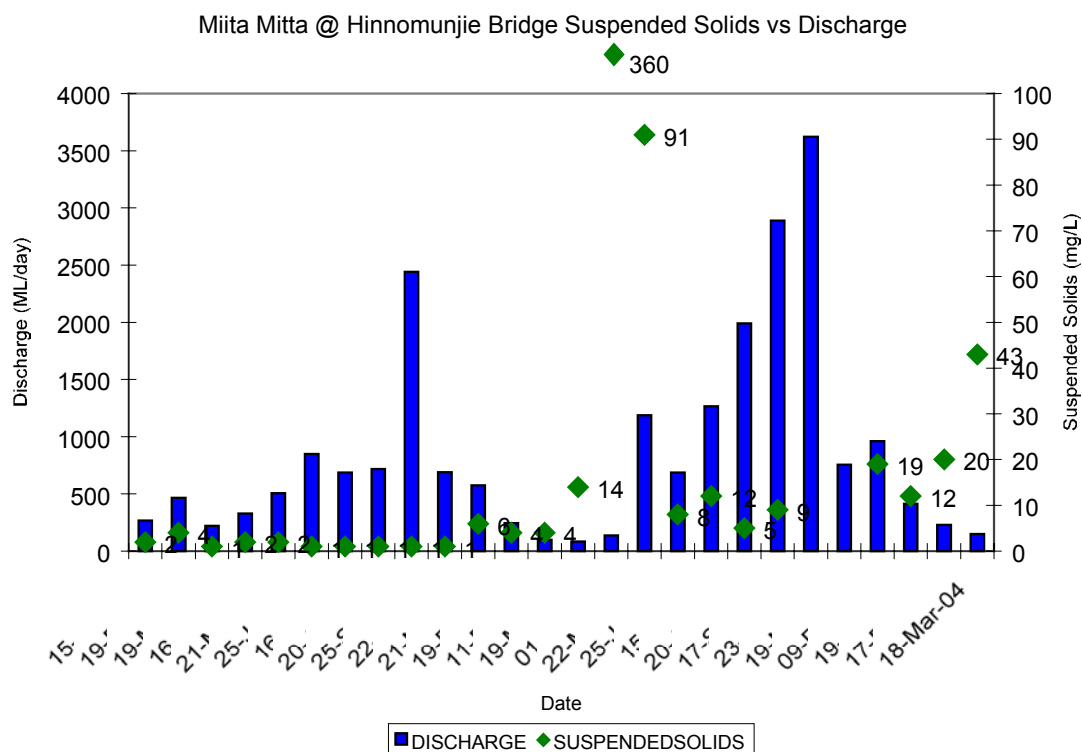


Figure 2.1.12 -Discharge (ML/Day) at the Miita Mitta River @Hinnomunjie Bridge Jan 2002 until Mar 2003 vs Suspended Solids (SS) (mg/L) ¹⁰

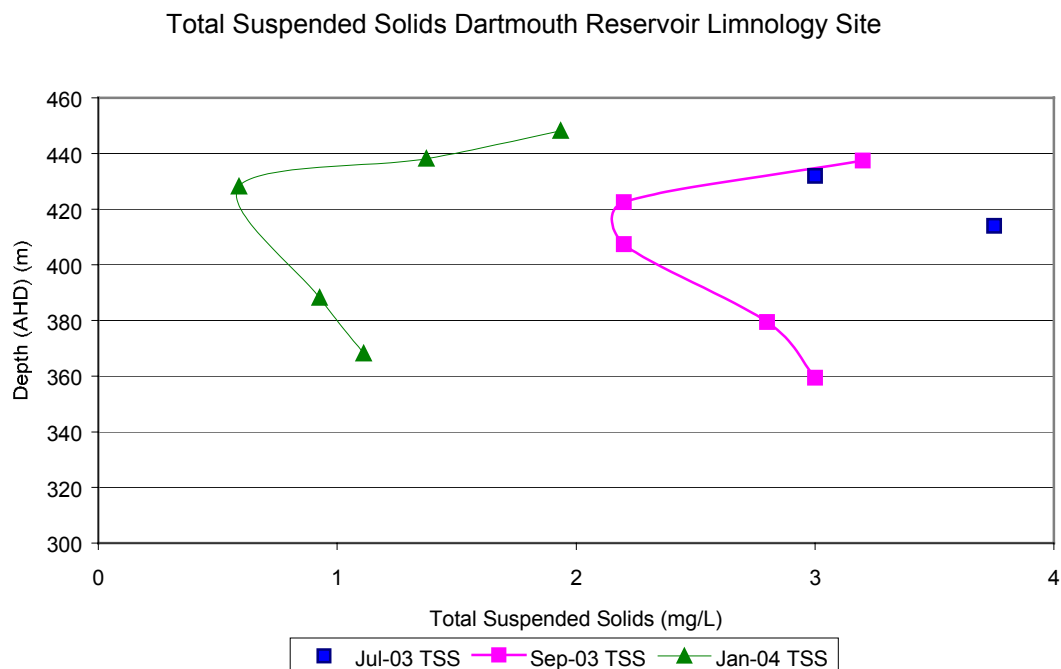


Figure 2.1.13-Total Suspended Solids (mg/L) Dartmouth Reservoir Limnology

Site

¹⁰ Data Obtained From www.vicwaterdata.net

Depth (m)	% Light Transmitted	
	28-Oct-03	12-Jan-04
0	100.00 %	100.00 %
0.1	49.72 %	
0.2	38.96 %	
0.3	36.14 %	38.30 %
0.4	33.57 %	33.50 %
0.5	29.56 %	35.50 %
0.6	28.30 %	28.40 %
0.7	29.72 %	23.50 %
0.8	29.72 %	28.50 %
0.9	28.95 %	26.30 %
1	26.91 %	24.50 %
1.1	23.81 %	22.80 %
1.2	23.26 %	21.70 %
1.5	18.95 %	20.90 %
2	13.51 %	13.90 %
2.5	8.12 %	8.00 %
3	6.93 %	3.30 %
3.5	5.39 %	
4	3.70 %	1.90 %
4.5	2.79 %	
5	1.81 %	1.20 %
5.5	0.66 %	
6	0.24 %	0.70 %
6.5	0.17 %	
7	0.00 %	0.40 %
7.5	0.00 %	
8	0.00 %	0.20 %
8.5		
9	0.10 %	
9.5		
10	0.10 %	
11	0.08 %	

Figure 2.1.14–Light Profile (%), Dartmouth Reservoir Limnology

Site

2.1.3 Does the delivery of nutrient and sediment affect the likelihood of algal bloom development in both the short (1-2 year) and longer term (5+ years)?

Chlorophyll-a concentrations in the surface waters of Dartmouth Reservoir (Figure 2.1.15) remained at $<4\mu\text{g/L}$ from Sep-03 until Jan-04. It is unclear if the Chlorophyll-a concentrations are increasing in the Reservoir, as there are no pre-fire measurements available. According to Water Quality Guidelines, values less than $5\mu\text{g/L}$ are acceptable for freshwater lakes and reservoirs[6], thus concentrations of Chlorophyll-a measured in the surface waters of the Reservoir do not exceed trigger values. At this early stage the likelihood of algae blooms has not been explored via modeling tools- this will be explored in future reports.

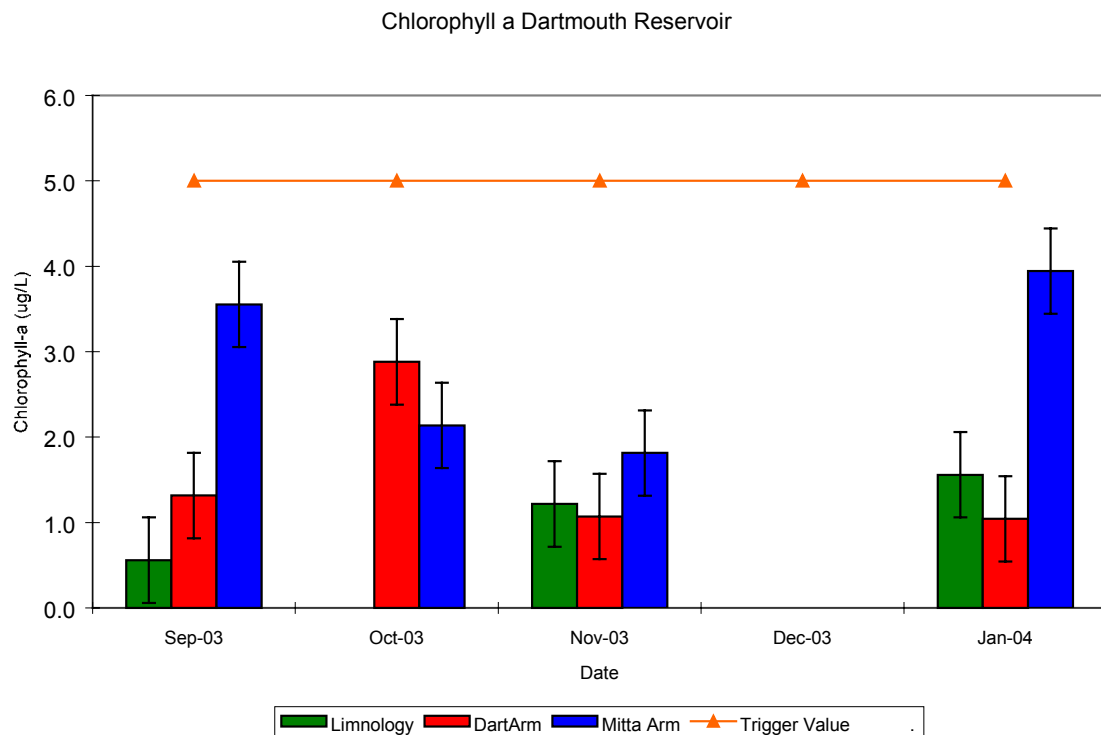


Figure 2.1.15 – Change in Chlorophyll a ($\mu\text{g/L}$) over time, Dartmouth Reservoir

2.1.4 Will there be water quality deterioration in these water-bodies due to increased turbidity?

As seen in the previous section, when TSS concentrations increased there was a significant increase in the turbidity measured. Water quality parameters such as electrical conductivity (EC), DO and pH were seen to change marginally when there were high turbidity measurements observed. For example¹¹ during May-03 the turbidity was 28 NTU (Discharge: 1188ML/Day) the EC 49 μ S/cm, pH 6.5 and DO 89%Sat compared with Nov-01, a pre-fire year, where the turbidity was 2NTU (Discharge: 1139ML/Day) with EC 31 μ S/cm, pH 7 and DO 100%Sat. It is unlikely that TSS is the causative factor influencing EC, pH and DO. It is possible that the increase in TSS is the result of the wash-in of particular matter from the catchment, while changes in EC is due to the wash-in of soluble ions (eg Na⁺, K⁺, Cl⁻ etc) and DO is lower due to increased respiration associated with high organic matter content in the water column.

There has not yet been any change evident for water quality parameters such as EC and pH in the surface waters of the reservoir at the Limnology site compared with pre-fire data, while turbidity appeared to have increase marginally. For example in the surface waters at the Limnology site during Oct-02 EC was 41 μ S/cm, pH 7.6 and Turbidity was 1 NTU¹² in comparison with Oct-03, post fire, EC was 42 μ S/cm, pH 7 and Turbidity was 5 NTU. It is apparent that there is little to no change in the turbidity and water quality of Dartmouth Reservoir's surface waters.

¹¹ Data obtained from www.vicwaterdata.net

¹² Data from Goulburn-Murray Water

2.1.5 Will respiration in receiving waters be enhanced by bushfire-related detritus, thereby causing anoxia and potential nutrient and toxicant release?

Several attempts have been made to collect sediment from the Reservoir. A corer deployed in Nov-03 was unsuccessful at retrieving material from the bottom of the Reservoir. In Feb-04 a small Ekman Sediment Grab was deployed with little success- a larger grab will be deployed in future months.

During Jul-03 a large body of apparent fire-borne material washing into the reservoir and was seen to be floating on the surface of the reservoir in both the Mitta Mitta River (Figure 2.1.16) and Dart River Arms. In the Mitta Arm of the reservoir the material covered the surface over 2 sections of approximately 100m in length approx 20cm thick. The majority of the material had dissipated by the following field trip in Sep-03. This material was collected and carbon content as well as settling rates will be determine for future reports. It is too early to say if bushfire-related detritus enhances respiration in Dartmouth Reservoir. This will depend on how resistant the burnt material is to microbial decomposition.



Figure 2.1.16- Mitta Mitta Arm Dartmouth Reservoir July 2003. Photo Taken by Sarah Alexander

2.2 Tambo River

2.2.1 What increases in nutrient concentration occur, as a result of the fires, at sites on the Tambo River?

Nutrient concentrations along the length of the Tambo River were found to increase significantly compared with pre-fire years. (Noting that the Johnsonville Site, located at the river's mouth, does not have any pre-fire data available)

Significant increases in Total Nitrogen (TN) were evident during Jul-03, Sep-03 and Dec-03 for sites up stream of the Johnsonville Site. For example at the Swifts Creek site, concentrations of TN¹³ increased from an average of 0.20 mg/L¹⁴ during Jul-01 to a concentration of 1.6mg/L of TN in Jul-03 which represents a 8-fold increase (Daily flow: Jul-03 113ML/day and Jul-01 116ML/Day).

TN at the Johnsonville site (Figure 2.2.1) averaged 0.28mg/L during the majority of the study period, during Dec-03 TN concentration of 1.2mg/L was detected in the surface waters, this is an increase 5 fold in comparison with previous months tested. According to Water Quality Guidelines[6], an 0.3mg/L of TN is trigger value set for estuarine systems thus the 1.2ug/L is 4 times greater than the trigger value set.

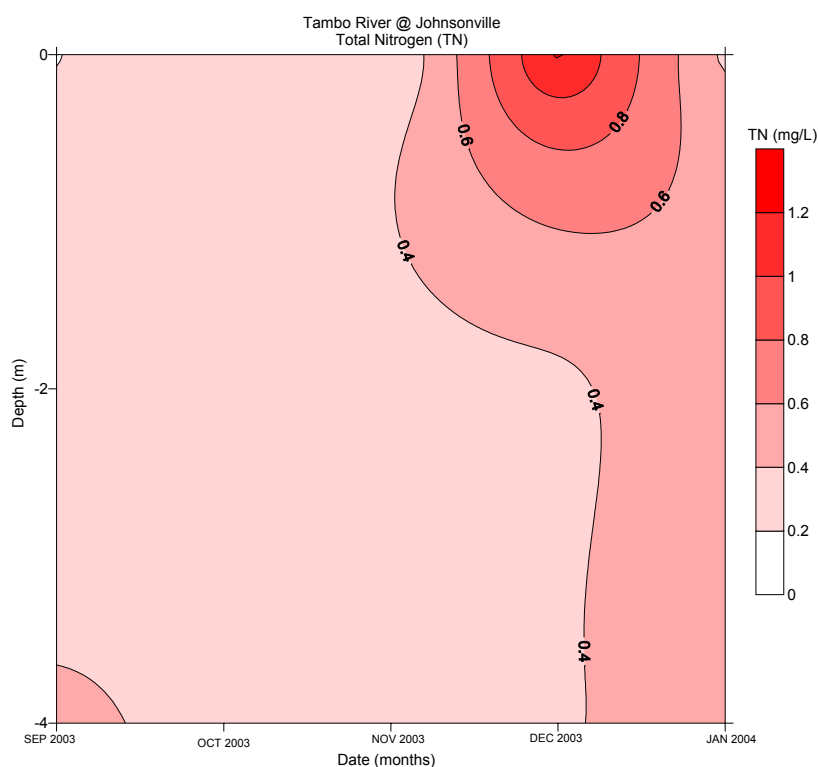


Figure 2.1.1 –Depth-time profile of isopleths¹⁵ of Total Nitrogen (mg/L), Tambo River at Johnsonville

^{13/14/15} TN is assumed to be the sum of NO_x and TKN

¹⁴ Data obtained from www.vicwaterdata.net

¹⁵ Isopleths: Discrete values as indicated by tick marks on the x and y axis. Values where only gathered for the x and y tick marks, the Graphic package, Surfer Version 7.04 interpolated intermediate values through estimation.

Nitrite/Nitrate (NO_x) concentrations were also found to increase compared with pre-fire years. Previous data was only available for the Smiths Creek and Swifts Creek Sites. During Jul-03 NO_x concentrations were seen to increase 32-fold at Swifts Creek in comparison to pre-fire previous months with similar average daily flow; increasing from $30\mu\text{g/L}$ ¹⁶ NO_x in Jul-01 to $970\mu\text{g/L}$ NO_x in Jul-03.

NO_x concentrations at Johnsonville (Figure 2.2.2) also increased throughout the surface waters during Sep-03 and Dec-03, where values of $45\mu\text{g/L}$ at Johnsonville were detected during Dec-03.

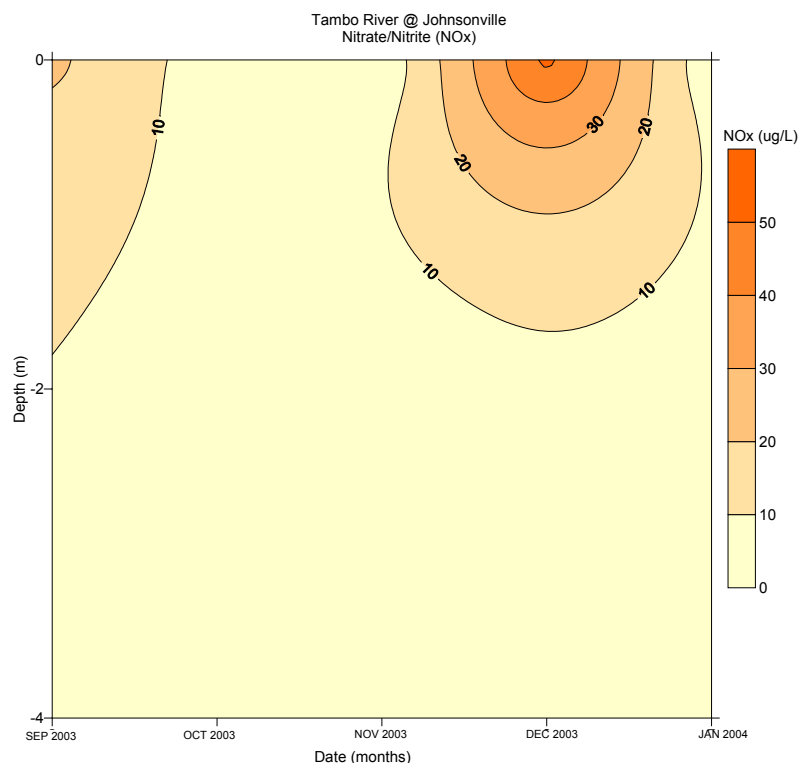


Figure 2.2.2 –Depth-time profile of isopleths¹⁷ of Nitrate/Nitrite ($\mu\text{g/L}$), Tambo River at Johnsonville

Ammonia (NH_4^+) was not previously tested in the Tambo River, however values of $64\mu\text{g N/L}$ of NH_4^+ were measured at Swifts Creek in Jul-03 in comparison to $12\mu\text{g N/L}$ in Jan-04. Future measurements will help to determine if this is a change due to the bushfire or is a seasonal variation, for example, lower summer time NH_4^+ may be explained by greater biological uptake due to faster cell growth in algae and macrophytes. NH_4^+ measurements at Johnsonville, (Figure 2.2.3) showed a higher concentration during Dec-03, with a peak of $32\mu\text{gN/L}$ of NH_4^+ throughout the water column in comparison to previous months where NH_4^+ was $<15\mu\text{g N/L}$.

Total Phosphorus (TP) and Filterable Reactive Phosphorus (FRP) also increased significantly for all Tambo Sites during the study period (excluding Nov-03) when compared with pre-fire data. For example at the Swifts Creek site TP increased from a pre-fire concentration of $20\mu\text{g/L}$ in Jul-01 to $144\mu\text{g/L}$ during Jul-03.

¹⁶ Data obtained from www.vicwaterdata.net

¹⁷ See Footnote 15

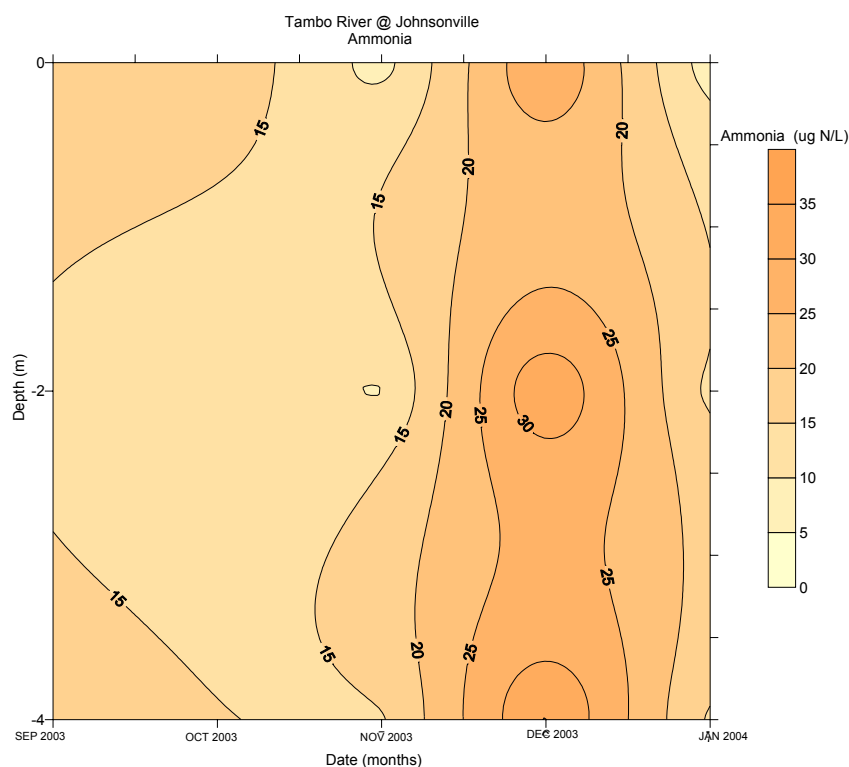


Figure 2.2.3—Depth-time profile of isopleths¹⁸ of Ammonia (ug N/L), Tambo River at Johnsonville

At Johnsonville the average concentrations of TP (Figure 2.2.4) was 20µg/L and FRP (Figure 2.2.5) 7µg/L measured during all months tested preceding Dec-03. During Dec-03 TP concentrations of 73µg/L in the surface layers and an FRP average of 17µg/L in the water column were detected.

High nitrogen and phosphorus concentrations were also detected during key rain events via the autosampler deployed at Swifts Creek. During the study period a number of rain events triggered the sampler. For example, a rain event in Aug-03 detected TN (Figure 2.2.6) concentrations of 56mg/L and TP (Figure 2.2.7) concentrations of 8.3mg/L during the peak of the event. These results are invaluable for calculating nutrient loads being transported via the Tambo River into the Gippsland Lakes. The longer-term deployment of autosamplers will help to determine the post bushfire time frame for increased nutrient concentrations in rivers with burnt catchments.

The data thus far have shown that nutrient concentrations have increased along the length of the Tambo River and the high concentrations detected at Johnsonville in Dec-03 are assumed to have been delivered to the Gippsland Lakes. It appears that the river has maintained higher nutrient concentrations for much of the preliminary study period which is in support of other studies which found nutrient concentrations in burnt streams to increase post fire[3].

¹⁸ See Footnote 15

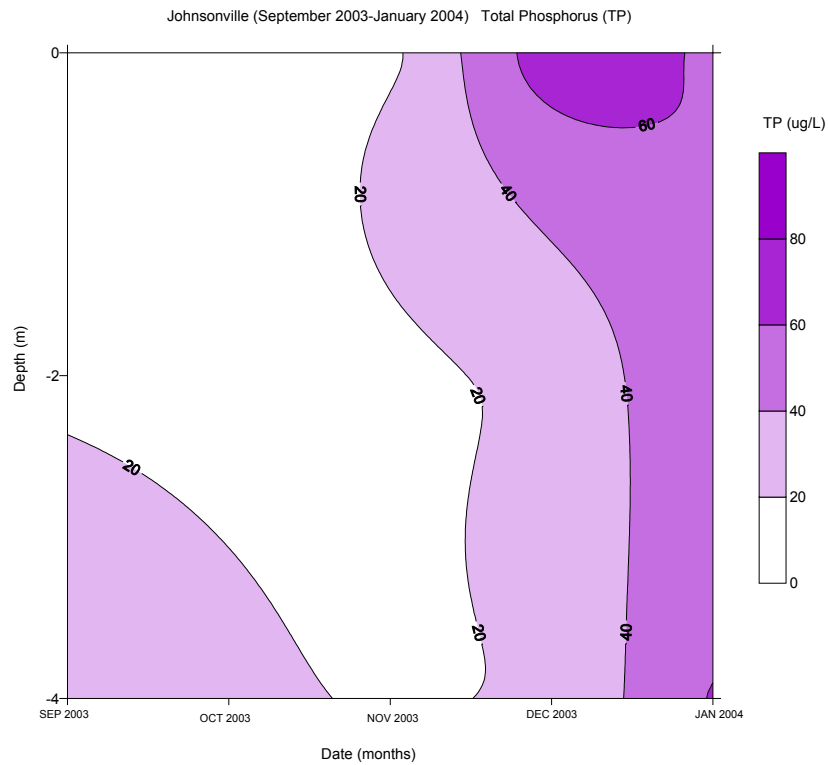


Figure 2.2.4—Depth-time profile of isopleths¹⁹ of Total Phosphorus ($\mu\text{g/L}$), Tambo River at Johnsonville

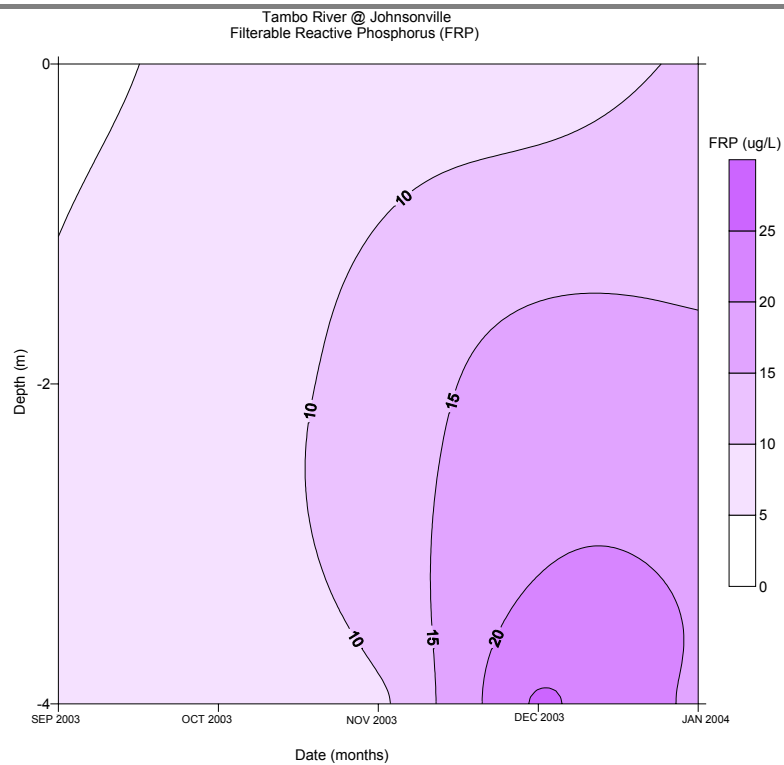
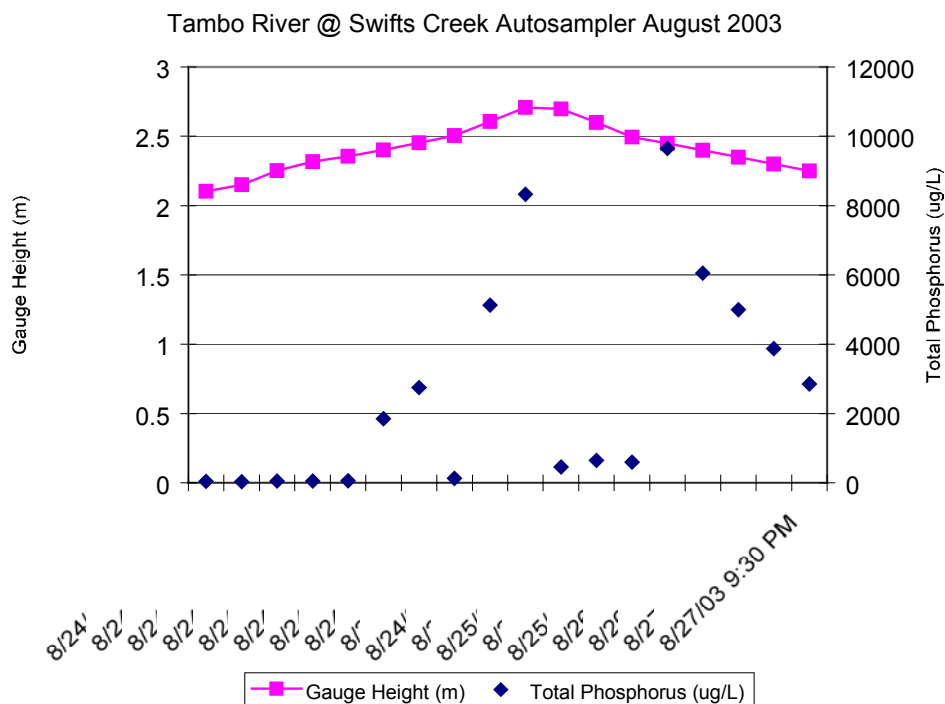


Figure 2.2.5—Depth-time profile of isopleths²⁰ of Filterable Reactive Phosphorus ($\mu\text{g/L}$), Tambo River at Johnsonville

¹⁹ See Footnote 15

²⁰ See Footnote 15



2.2.2 What impact does the delivery of high nutrient and sediment loads from the bushfire areas have on the Tambo River Mouth, Johnsonville?

At some sites, suspended sediment concentrations along the length of the Tambo River (Figures 2.2.8-2.2.10) have been significantly greater than those in pre-fire years. For example at Swifts Creek; during Jul-03 a TSS of 122mg/L was measured when average daily flows recorded 113ML/Day in comparison with Jul-01, which had a TSS of 2mg/L with average daily flow of 116mL/day. This comparison is valid as the average daily flows are comparable and the river flow profile prior, to the testing days highlighted, is of a similar volume. With increased TSS there was also an increase in the turbidity of the water. For example at Ramrod Creek in Dec-03 a turbidity of 337 NTU was measured along with a TSS of 157mg/L in comparison with an early reading in Oct-03 where Turbidity was 5 NTU and TSS was 1mg/L.

There has not been a definable trend seen concurrently at all sites tested. Although TSS increased significantly at Swifts Creek the magnitude of increase was not necessarily mirrored at Smiths Creek. Factors such as logging, 4WD driving and cattle grazing would need to be taken into consideration before coupling increases in TSS with bushfires at Smiths Creek as TSS were randomly high preceding the bushfire.

Total Organic Carbon (TOC) concentrations along the length of the Tambo River were not necessarily high when TSS concentrations were and did not follow a noticeable trend. This suggests that carbon may not be a significant proportion of the suspended solid composition being transported.

On average, the Total Suspended Solids concentration (Figure 2.2.11) at the Johnsonville site was 6 mg/L within the surface waters for the preliminary study period. This may be attributed to salinity-induced coagulation of particles and subsequent settling as conductivity was similar month to month. During Dec-03, concentrations of 23mg/L TSS in the surface waters were detected, while the underlying waters continued to have a TSS concentration <6 mg/L.

The high load of suspended solids in Dec-03 appears to have contributed to the change in the % of light transmitted. (Figure 2.2.12) Prior to Dec-03 at Johnsonville the euphotic depth extended down to 4m to reach the sediment, thus the entire water column and surface sediments could support photosynthesis. In Dec-03 the euphotic depth only extended to 50cm below the surface, thus only 12% of the column could support photosynthesis thus less phytoplankton and potential problems for benthic algae.

At this stage, the Tambo River has had significant increases in both nutrients (see Section 2.2.1) and suspended sediment concentrations post bushfire. Suspended sediment concentrations have changed the euphotic depth at the river's mouth. Impacts such as anoxic waters and algae blooms, caused by high nutrient and sediment loads have not been seen to date and will be discussed further in subsequent sections of this report.

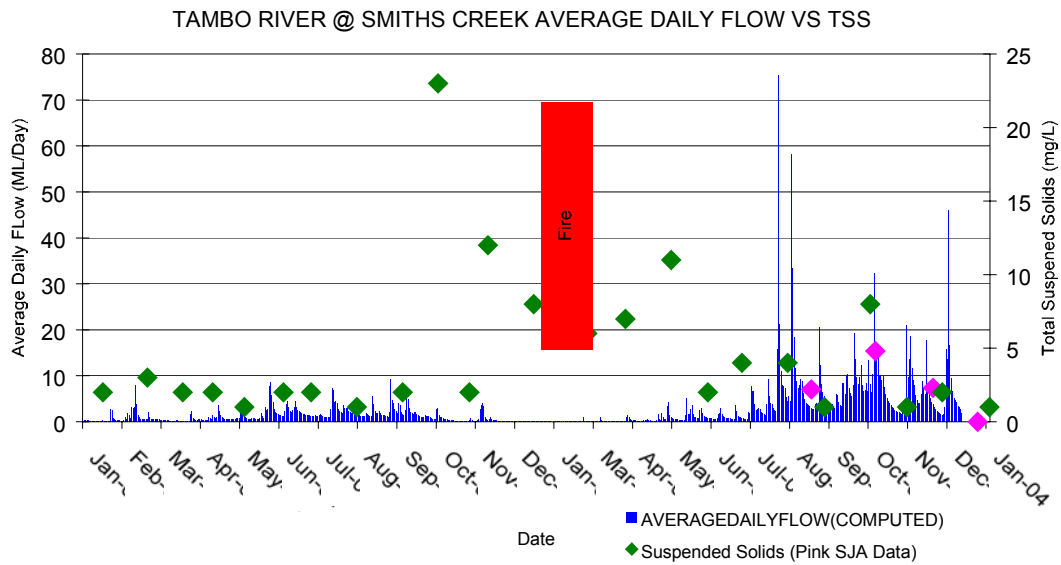


Figure 2.2.8 –Average Daily flow the Tambo River @Smiths Creek Jan-02 until Nov-2003 vs. Total Suspended Solids.

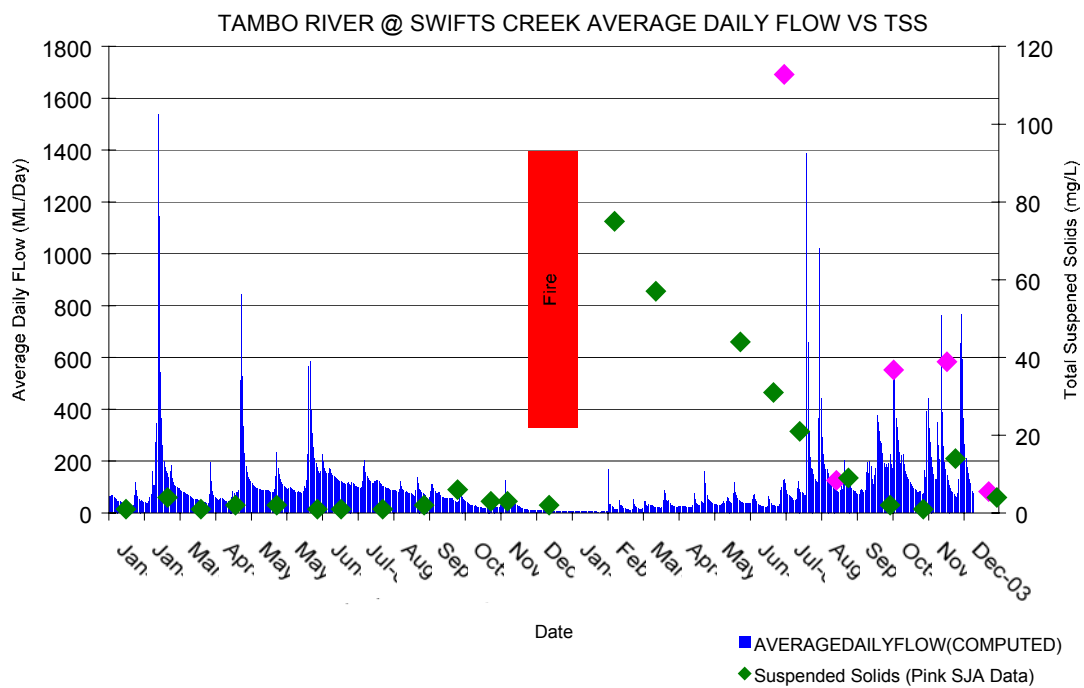


Figure 2.2.9–Average Daily flow the Tambo River @ Swifts Creek Jan-02 until Nov-2003 vs Total Suspended Solids.

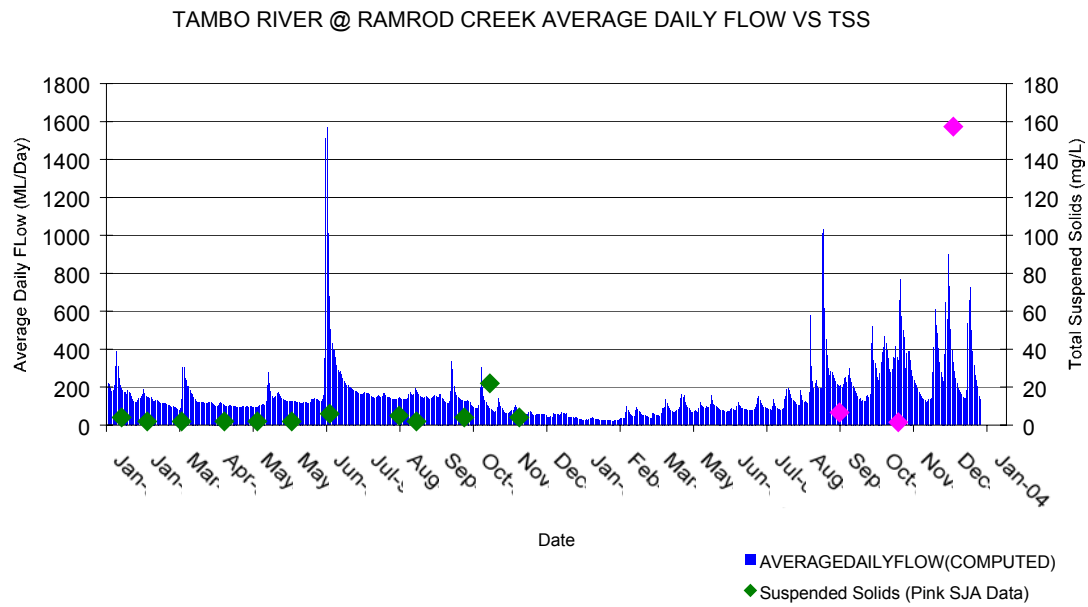


Figure 2.2.10 –Average Daily flow the Tambo River @ Ramrod Creek Jan-02 until Nov-2003 vs. Total Suspended Solids.

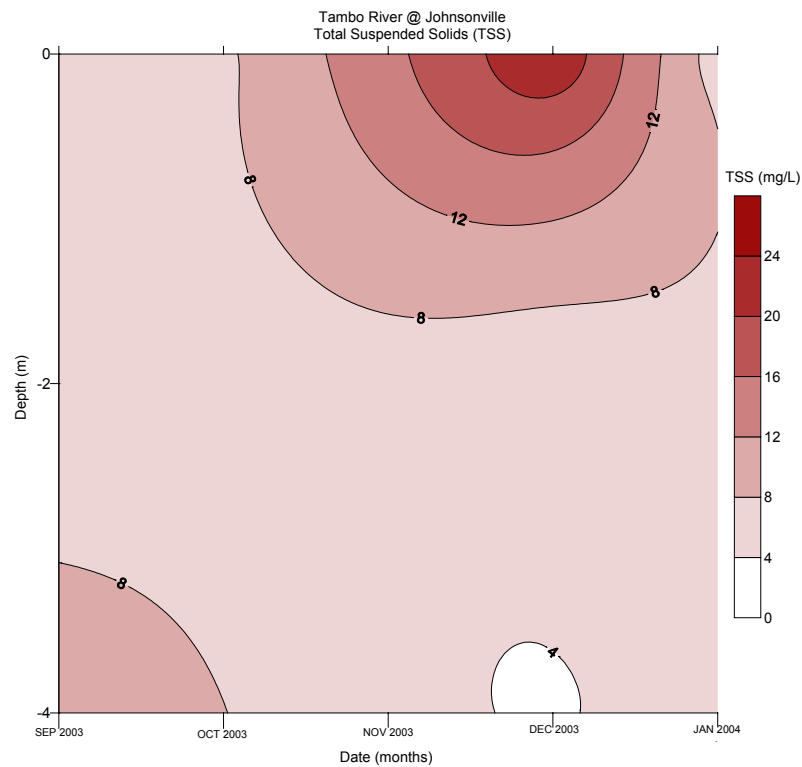


Figure 2.2.11 –Depth-time profile of isopleths²³ of Total Suspended Solids (mg/L), Tambo River at Johnsonville.

²³ See Footnote 15

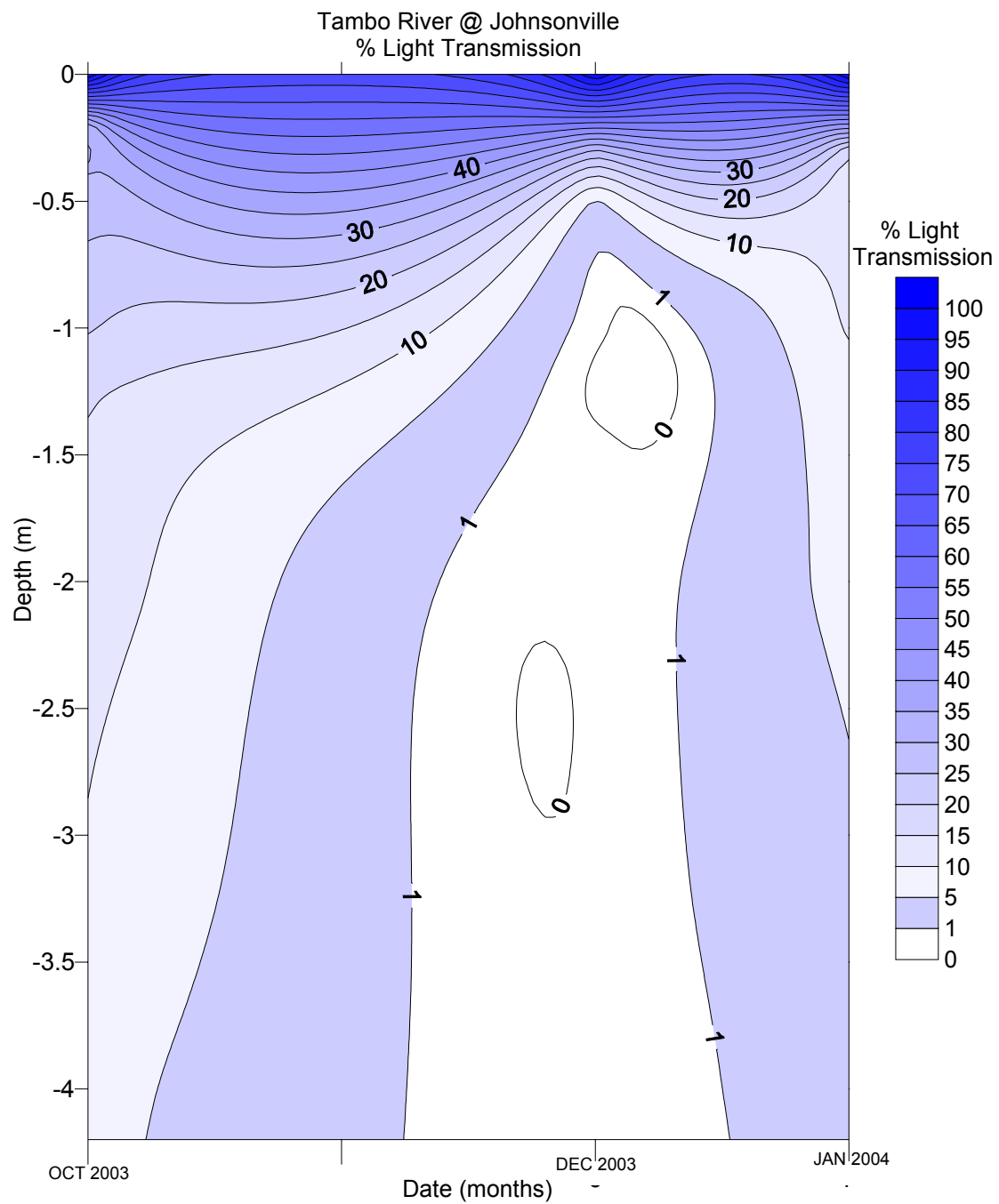


Figure 2.2.12 –Depth-time profile of isopleths²⁴ of transmission of Light (%), Tambo River at Johnsonville.

²⁴ See Footnote 15

2.2.3 Does the delivery of nutrient and sediment affect the likelihood of algal bloom development in both the short (1-2 year) and longer term (5+ years)?

Chlorophyll-a levels at Johnsonville (Figure 2.2.13) were found to steadily increase from Sep-03 until Jan-04, with all Chlorophyll-a concentrations $< 2.5 \mu\text{g/L}$. The increased in chlorophyll-a followed a similar pattern as the water temperature suggesting increases in Chlorophyll-a are probably due to more favorable growing temperatures (and longer periods of daylight). During Dec-03, only 12% of the water column could support photosynthesis due to high TSS and turbidity (see Section 2.2.2), the chlorophyll-a concentrations appeared to plateau marginally. According to Water Quality Guidelines values less than $4 \mu\text{g/L}$ are acceptable for estuaries[6], thus concentrations of Chlorophyll-a measures at the Johnsonville site thus far do not exceed trigger values. At this early stage, the likelihood of algae blooms has not been explored via modeling tools, however this will be done in future reports.

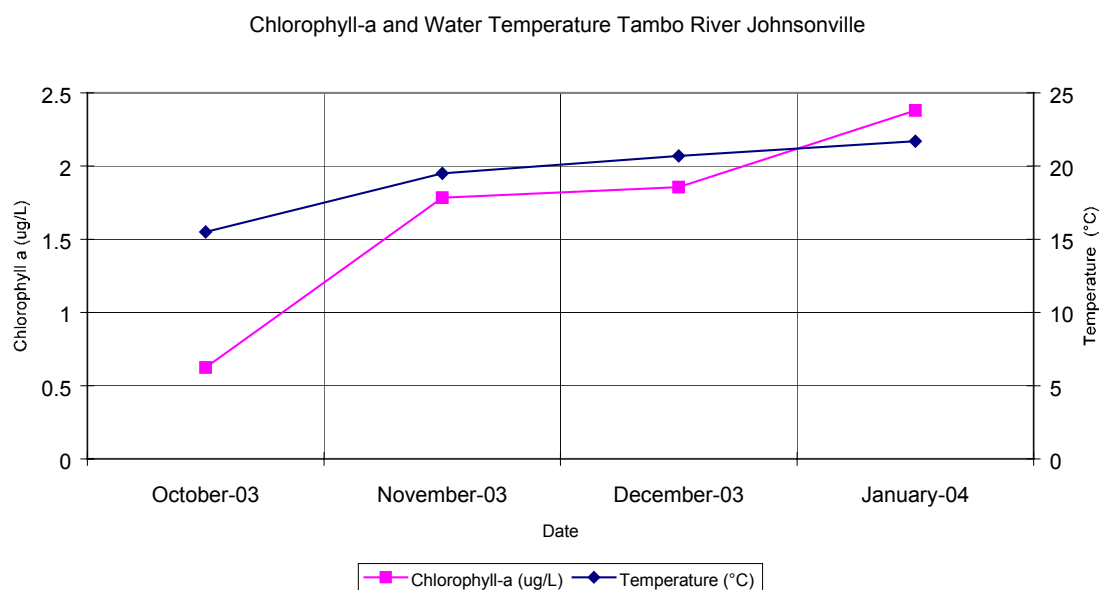


Figure 2.2.13 –Change in Chlorophyll-a ($\mu\text{g/L}$) vs. Water Temperature (degree) in surface waters over time, Tambo River at Johnsonville

2.2.4 Will there be water quality deterioration in these water-bodies due to increased turbidity?

As seen in section 2.2.2, when TSS concentrations increased there was a significant increase in the turbidity measured. Water quality parameters such as electrical conductivity and dissolved oxygen (Figure 2.2.14) were seen to increase marginally when there were high turbidity measurements observed, whereas parameters such as pH remained within the same ranges irrespective of the turbidity of the water. For example when turbidity exceeded 20NTU DO was seen to be greater than 88% and then turbidity was less than 20NTU DO was less than 77% at Swifts Creek. One likely explanation could be that when high turbidity was detected, the average daily flow of the river was above 100ML/day, thus the velocity of the river's water was also potentially greater. Hence the increased DO was due to enhance reaeration from the mechanical turbulence of the water as opposed to algal DO production.

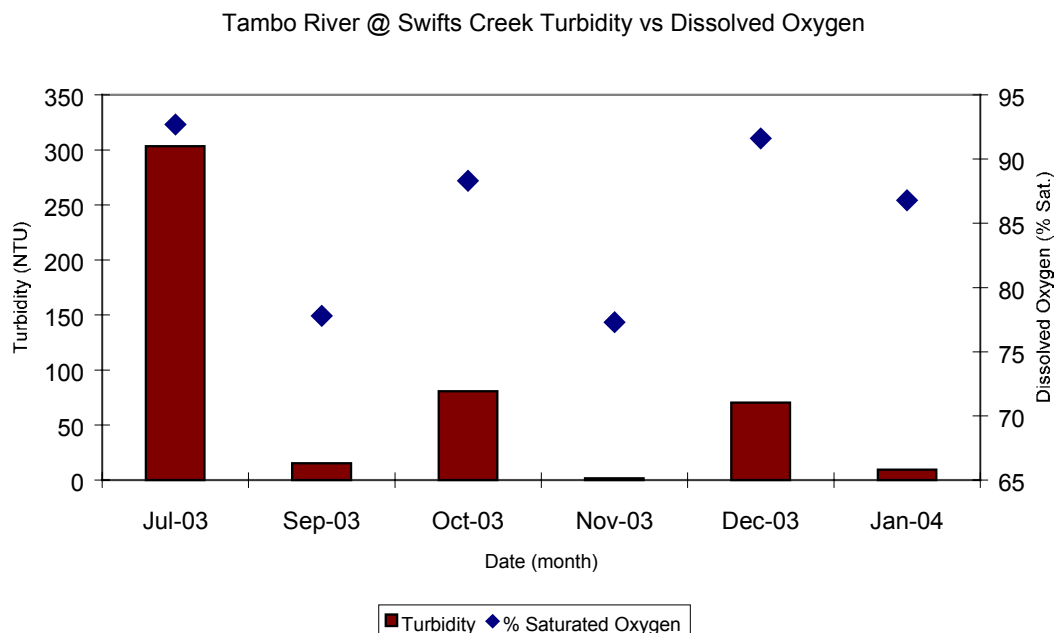


Figure 2.2.14- Tambo River at Swifts Creek Turbidity (NTU) vs. Dissolved Oxygen (%Sat)

At the Johnsonville site, water quality variables such as pH, DO and electrical conductivity (salinity) did not vary during the study periods and high turbidity measurements were not observed. For example (Figure 2.2.15) in Dec-03; turbidity in the surface waters was 6NTU and EC was 30ms/cm, in comparison to Sep-03 where Turbidity was 2NTU in the surface waters and EC was 33ms/cm. The Johnsonville site was well mixed and did not have a “salt wedge” for the majority of the study period, except during Oct-03 when there was a band of marginally less saline water in the top of the water column (Figure 2.2.16).

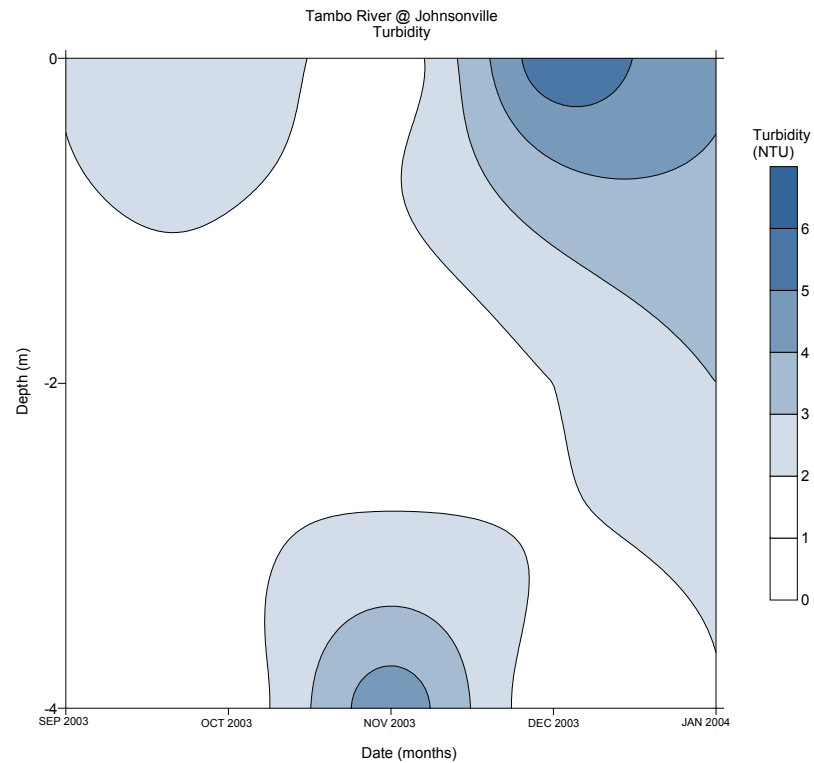


Figure 2.2.15 –Depth-time profile of isopleths²⁵ of Turbidity (NTU), Tambo River at

Johnsonville.

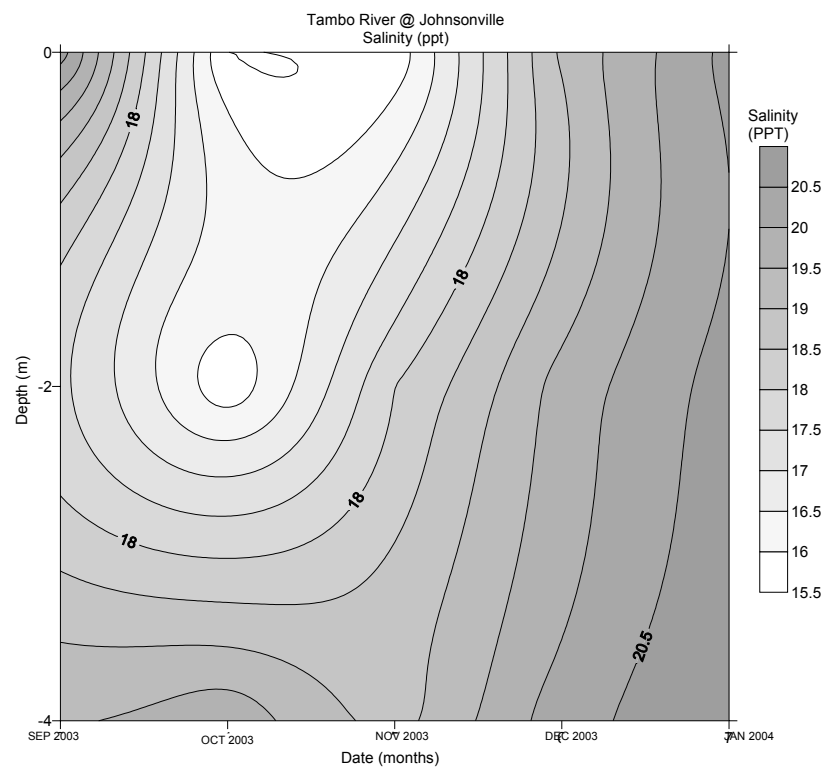


Figure 2.2.16 –Depth-time profile of isopleths²⁶ of Salinity (ppt), Tambo River at

Johnsonville.

²⁵ See Footnote 15

²⁶ See Footnote 15

2.2.5 Will respiration in receiving waters be enhanced by bushfire-related detritus, thereby causing anoxia and potential nutrient and toxicant release?

At this stage several attempts have been made to collect sediment from the River's mouth. A corer deployed in Nov-03 was unsuccessful at retrieving material from the River's bottom. In Feb-04 an Ekman Sediment Grabber was deployed and some sediment retrieved it showed evidence of small pieces of carbon (probably from the bushfires). A larger grabber will be deployed in future months. At this stage it is unknown if respiration in the Tambo River mouth will be enhanced as a result of the bushfires. It may be suggested, admittedly on the basis of very limited data thus far from Fig. 2.2.15, that suspended solids in the water column are not easily broken down (respired). Perhaps one finding from this work is that the ash from severe bushfires is effectively non-bioavailable hence will not enhance respiration, anoxia and nutrient release. This suggestion will be investigated during the rest of the project.

3. Conclusion

Since sampling began in July 2003, major progress has been made investigating the key focus questions. There have been high nutrient and suspended solid concentrations detected in both the Tambo and Dartmouth systems. No large impact of this high nutrient and suspended solid loaded water on the receiving waterbodies has yet been observed. Preliminary algal, chlorophyll-a concentrations have been captured and the use of a modeling tool will help to determine the potential for algae bloom development for future reports. In coming months it is anticipated that sediment will be retrieved from both systems and respiration potentials determined.

At this stage, project objectives are on the way to be fully investigated and project timelines adhered to.

4. Glossary

AHD:

Australian height datum

benthic algae:

bottom dwelling algae, algae located on or near the sediments of a river, lake or reservoir

euphotic depth:

the depth at which a body of water receives sufficient light for photosynthesis, where light transmitted is $>1\%$ of incident light.

macrophytes:

small (macroscopic) plants

meromictic:

a lake or reservoir with 2 layers of water which do not mix

mixolimnion:

The upper layer of water in a meromictic lake/reservoir

monimolimnion:

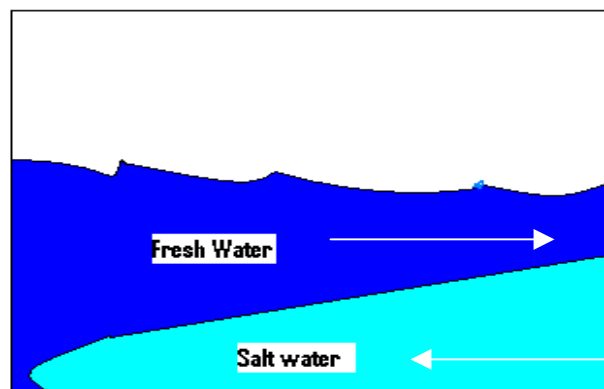
The lower or deep layer of water below the mixolimnion

phytoplankton:

free floating photosynthetic microorganism contained in water

salt wedge:

a band of saltwater which may travel up a freshwater river from an ocean/bay/lake. As salt water is more dense than fresh water the salt water wedge remains below the fresh water.



6. Bibliography

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Appendix 1: Dartmouth Tributaries Nutrients

Date	Location	Total Nitrogen	Nitrite/Nitrate	Ammonia	Total Phosphorus	Filterable Reactive Phosphorus
25-Jul-03	Big River	1.40 mg/L	884 µg/L	56 µg/L	99 µg/L	41 µg/L
6-Sep-03	Big River	0.53 mg/L	188 µg/L	5 µg/L	29 µg/L	7 µg/L
27-Oct-03	Big River	0.32 mg/L	267 µg/L	11 µg/L	10 µg/L	7 µg/L
14-Nov-03	Big River	0.01 mg/L	57 µg/L	7 µg/L	214 µg/L	3 µg/L
13-Jan-04	Big River	0.02 mg/L	65 µg/L	9 µg/L	307 µg/L	6 µg/L
28-Jul-03	Dart River	1.34 mg/L	1078 µg/L	39 µg/L	52 µg/L	6 µg/L
28-Oct-03	Dart River	0.25 mg/L	287 µg/L	5 µg/L	10 µg/L	6 µg/L
13-Nov-03	Dart River	0.01 mg/L	174 µg/L	5 µg/L	286 µg/L	10 µg/L
12-Jan-04	Dart River	0.01 mg/L	84 µg/L	9 µg/L	172 µg/L	2 µg/L
25-Jul-03	Hinnomunjie Bridge	9.04 mg/L	18 µg/L	8 µg/L	1993 µg/L	1 µg/L
24-Aug-03	Hinnomunjie Bridge	7.81 mg/L	920 µg/L	61 µg/L	1891 µg/L	35 µg/L
6-Sep-03	Hinnomunjie Bridge	0.29 mg/L	189 µg/L	17 µg/L	14 µg/L	12 µg/L
27-Oct-03	Hinnomunjie Bridge	0.46 mg/L	215 µg/L	16 µg/L	19 µg/L	9 µg/L
14-Nov-03	Hinnomunjie Bridge	0.32 mg/L	22 µg/L	8 µg/L	444 µg/L	4 µg/L
13-Jan-04	Hinnomunjie Bridge	0.02 mg/L	32 µg/L	3 µg/L	308 µg/L	8 µg/L

Appendix 2: Dartmouth Nutrients Limnology Site

Date	AHD (m)	Total Nitrogen	Nitrite/Nitrate	Ammonia	Total Phosphorus	Filterable Reactive Phosphorus
Limnology Site						
28-Jul-03	431.97	0.25 mg/L	17 µg/L	29 µg/L	11 µg/L	3 µg/L
28-Jul-03	413.97	0.17 mg/L	19 µg/L	33 µg/L	11 µg/L	3 µg/L
28-Jul-03	390.97	0.17 mg/L	3 µg/L	22 µg/L	17 µg/L	5 µg/L
28-Jul-03	356.97	0.28 mg/L	4 µg/L	192 µg/L	41 µg/L	3 µg/L
28-Jul-03	324.97	0.32 mg/L	3 µg/L	240 µg/L	56 µg/L	4 µg/L
2-Sep-03	437.44	0.44 mg/L	44 µg/L	36 µg/L	19 µg/L	4 µg/L
2-Sep-03	422.44	0.20 mg/L	51 µg/L	34 µg/L	18 µg/L	5 µg/L
2-Sep-03	407.44	0.19 mg/L	26 µg/L	39 µg/L	18 µg/L	4 µg/L
2-Sep-03	382.44	0.35 mg/L	169 µg/L	42 µg/L	22 µg/L	4 µg/L
2-Sep-03	359.44	1.03 mg/L	746 µg/L	47 µg/L	31 µg/L	9 µg/L
2-Sep-03	347.44		886 µg/L	21 µg/L		8 µg/L
28-Oct-03	444.13	0.28 mg/L	111 µg/L	12 µg/L	19 µg/L	6 µg/L
13-Nov-03	445.44	0.22 mg/L	74 µg/L	10 µg/L	5 µg/L	3 µg/L
13-Nov-03	411.44	0.23 mg/L	108 µg/L	6 µg/L	6 µg/L	0 µg/L
13-Nov-03	391.44	0.32 mg/L	167 µg/L	7 µg/L	7 µg/L	1 µg/L
13-Nov-03	360.44	0.76 mg/L	511 µg/L	8 µg/L	15 µg/L	5 µg/L
12-Jan-04	448.16	0.23 mg/L	15 µg/L	10 µg/L	7 µg/L	0 µg/L
12-Jan-04	438.16	0.34 mg/L	13 µg/L	12 µg/L	9 µg/L	1 µg/L
12-Jan-04	428.16	0.26 mg/L	95 µg/L	7 µg/L	7 µg/L	1 µg/L
12-Jan-04	388.16	0.33 mg/L	193 µg/L	6 µg/L	7 µg/L	3 µg/L
12-Jan-04	368.16	0.54 mg/L	295 µg/L	7 µg/L	11 µg/L	4 µg/L
12-Jan-04	348.16	0.83 mg/L	633 µg/L	5 µg/L	17 µg/L	6 µg/L

Appendix 3: Dartmouth Nutrients Dart Arm Site

Date	AHD (m)	Total Nitrogen	Nitrite/Nitrate	Ammonia	Total Phosphorus	Filterable Reactive Phosphorus
Dart Arm Site						
28-Jul-03	431.97	0.28 mg/L	30 µg/L	20 µg/L	9 µg/L	3 µg/L
28-Jul-03	419.97	0.27 mg/L	32 µg/L	20 µg/L	44 µg/L	3 µg/L
28-Jul-03	404.97	0.16 mg/L	20 µg/L	26 µg/L	6 µg/L	2 µg/L
28-Jul-03	401.97	0.20 mg/L	11 µg/L	49 µg/L	16 µg/L	2 µg/L
28-Jul-03	399.97	0.21 mg/L	0 µg/L	42 µg/L	14 µg/L	5 µg/L
2-Sep-03	437.44	0.45 mg/L	136 µg/L	27 µg/L	17 µg/L	5 µg/L
2-Sep-03	430.44	0.33 mg/L	49 µg/L	16 µg/L	12 µg/L	3 µg/L
2-Sep-03	421.44	0.53 mg/L	114 µg/L	23 µg/L	17 µg/L	3 µg/L
2-Sep-03	402.44	0.45 mg/L			21 µg/L	
2-Sep-03	391.44	0.23 mg/L			14 µg/L	
28-Oct-03	444.13	0.26 mg/L	115 µg/L	12 µg/L	16 µg/L	8 µg/L
28-Oct-03	428.13	0.27 mg/L	141 µg/L	15 µg/L	11 µg/L	9 µg/L
28-Oct-03	412.13	0.29 mg/L	163 µg/L	5 µg/L	11 µg/L	3 µg/L
28-Oct-03	399.13	0.36 mg/L	219 µg/L	7 µg/L	16 µg/L	6 µg/L
28-Oct-03	384.13	0.23 mg/L	216 µg/L	9 µg/L	9 µg/L	6 µg/L
13-Nov-03	445.44	0.21 mg/L	35 µg/L	9 µg/L	5 µg/L	0 µg/L
13-Nov-03	435.44	0.23 mg/L	63 µg/L	9 µg/L	6 µg/L	1 µg/L
13-Nov-03	425.44	0.29 mg/L	92 µg/L	9 µg/L	5 µg/L	3 µg/L
13-Nov-03	403.44	0.34 mg/L	93 µg/L	7 µg/L	8 µg/L	1 µg/L
12-Jan-04	448.16	0.15 mg/L	7 µg/L	9 µg/L	7 µg/L	1 µg/L
12-Jan-04	438.16	0.24 mg/L	45 µg/L	11 µg/L	8 µg/L	0 µg/L
12-Jan-04	418.16	0.23 mg/L	93 µg/L	4 µg/L	7 µg/L	0 µg/L
12-Jan-04	398.16	0.30 mg/L	201 µg/L	6 µg/L	11 µg/L	2 µg/L

Appendix 4: Dartmouth Nutrients Mitta Mitta Arm Site

Date	AHD (m)	Total Nitrogen	Nitrite/Nitrate	Ammonia	Total Phosphorus	Filterable Reactive Phosphorus
Mitta Mitta Arm Site						
28-Jul-03	431.97	0.23 mg/L	28 µg/L	30 µg/L	12 µg/L	4 µg/L
28-Jul-03	415.97	0.20 mg/L	25 µg/L	14 µg/L		2 µg/L
28-Jul-03	397.97	0.62 mg/L	72 µg/L	18 µg/L	7 µg/L	2 µg/L
28-Jul-03	394.97	0.25 mg/L	87 µg/L	26 µg/L	41 µg/L	3 µg/L
28-Jul-03	386.97	0.53 mg/L	52 µg/L	90 µg/L	20 µg/L	8 µg/L
28-Jul-03	381.97		191 µg/L	28 µg/L	17 µg/L	3 µg/L
2-Sep-03	437.44	0.23 mg/L	68 µg/L	6 µg/L	14 µg/L	4 µg/L
2-Sep-03	422.44	0.24 mg/L	113 µg/L	13 µg/L	16 µg/L	5 µg/L
2-Sep-03	407.44	0.26 mg/L	117 µg/L	22 µg/L	16 µg/L	7 µg/L
2-Sep-03	385.44	0.71 mg/L		22 µg/L	30 µg/L	12 µg/L
28-Oct-03	444.13	0.27 mg/L	129 µg/L	13 µg/L	16 µg/L	9 µg/L
13-Nov-03	445.44	0.25 mg/L	42 µg/L	14 µg/L	6 µg/L	0 µg/L
13-Nov-03	435.44	0.25 mg/L	64 µg/L	10 µg/L	6 µg/L	0 µg/L
13-Nov-03	415.44	0.27 mg/L	1 µg/L	4 µg/L	5 µg/L	0 µg/L
13-Nov-03	395.44	0.34 mg/L	198 µg/L	6 µg/L	7 µg/L	2 µg/L
12-Jan-04	448.16	0.17 mg/L	9 µg/L	10 µg/L	6 µg/L	1 µg/L
12-Jan-04	438.16	0.43 mg/L	135 µg/L	10 µg/L	15 µg/L	3 µg/L
12-Jan-04	418.16	0.31 mg/L	132 µg/L	6 µg/L	10 µg/L	3 µg/L
12-Jan-04	398.16	0.34 mg/L	124 µg/L	6 µg/L	8 µg/L	3 µg/L

Appendix 5: Dartmouth Total Suspended Solids

Date	Location	Total Suspended Solids
25-Jul-03	Big River	28.37 mg/L
06-Sep-03	Big River	1.60 mg/L
27-Oct-03	Big River	3.44 mg/L
13-Nov-03	Big River	
13-Jan-04	Big River	1.91 mg/L
28-Jul-03	Dart River	68.50 mg/L
02-Sep-03	Dart River	8.50 mg/L
28-Oct-03	Dart River	5.41 mg/L
13-Nov-03	Dart River	
12-Jan-04	Dart River	3.76 mg/L
25-Jul-03	Hinnomunjie Bridge	84.60 mg/L
06-Sep-03	Hinnomunjie Bridge	4.20 mg/L
27-Oct-03	Hinnomunjie Bridge	4.66 mg/L
13-Nov-03	Hinnomunjie Bridge	
13-Jan-04	Hinnomunjie Bridge	3.13 mg/L

Limnology			Mitta Mitta Arm			Dart Arm		
Date	AHD (m)	TSS	Date	AHD (m)	TSS	Date	AHD (m)	TSS
28-Jul-03	431.97	3.00 mg/L	28-Jul-03	431.97	1.60 mg/L	28-Jul-03	431.97	
28-Jul-03	413.97	3.75 mg/L	28-Jul-03	415.97	2.20 mg/L	28-Jul-03	437.44	
28-Jul-03	390.97		28-Jul-03	397.97		28-Jul-03	437.44	
28-Jul-03	356.97		28-Jul-03	394.97		28-Jul-03	437.44	
28-Jul-03	324.97		28-Jul-03	386.97	4.86 mg/L	28-Jul-03	437.44	
02-Sep-03	437.44	3.20 mg/L	28-Jul-03	381.97		02-Sep-03	437.44	1.52 mg/L
02-Sep-03	422.44	2.20 mg/L	02-Sep-03	437.44	2.60 mg/L	02-Sep-03	430.44	1.80 mg/L
02-Sep-03	407.44	2.20 mg/L	02-Sep-03	422.44	2.40 mg/L	02-Sep-03	423.44	1.60 mg/L
02-Sep-03	379.44	2.80 mg/L	02-Sep-03	407.44	1.60 mg/L	02-Sep-03	416.44	1.40 mg/L
02-Sep-03	359.44	3.00 mg/L	02-Sep-03	385.44		02-Sep-03	409.44	5.80 mg/L
13-Nov-03	445.44		28-Oct-03	444.13	1.09 mg/L	28-Oct-03	444.13	6.66 mg/L
13-Nov-03	411.44		13-Nov-03	445.44		28-Oct-03	428.13	1.90 mg/L
13-Nov-03	391.44		13-Nov-03	415.44		28-Oct-03	412.13	1.38 mg/L
13-Nov-03	360.44		13-Nov-03	395.44		28-Oct-03	399.13	3.91 mg/L
12-Jan-04	448.16	1.94 mg/L	12-Jan-04	448.16	1.30 mg/L	13-Nov-03	445.44	
12-Jan-04	438.16	1.37 mg/L	12-Jan-04	438.16	3.68 mg/L	13-Nov-03	425.44	
12-Jan-04	428.16	0.6 mg/L	12-Jan-04	418.16	0.2 mg/L	13-Nov-03	403.44	
12-Jan-04	388.16	0.9 mg/L	12-Jan-04	398.16	1.56 mg/L	12-Jan-04	448.16	2.83 mg/L
12-Jan-04	368.16	1.11 mg/L				12-Jan-04	438.16	3.33 mg/L
						12-Jan-04	418.16	0.4 mg/L
						12-Jan-04	398.16	6.35 mg/L

Appendix 6: Dartmouth Light Profiles

Transmission of Light%						
Depth (m)	Limnology		Mitta Mitta Arm		Dart Arm	
	28-Oct-03	12-Jan-04	28-Oct-03	12-Jan-04	28-Oct-03	
0	100.00 %	100.00 %	100.00%	100.00%	100.00%	
0.1	49.72 %		57.21%		30.47%	
0.2	38.96 %		42.10%		27.61%	
0.3	36.14 %	38.30 %	39.08%	35.96%	25.44%	
0.4	33.57 %	33.50 %	34.97%	5.39%	22.59%	
0.5	29.56 %	35.50 %	33.84%	4.83%	20.92%	
0.6	28.30 %	28.40 %	32.44%	4.61%	17.59%	
0.7	29.72 %	23.50 %	29.90%	4.38%	15.31%	
0.8	29.72 %	28.50 %	27.08%	4.49%	14.26%	
0.9	28.95 %	26.30 %	24.98%	4.49%	12.68%	
1	26.91 %	24.50 %	23.74%	4.72%	11.10%	
1.1	23.81 %	22.80 %	22.41%	4.49%		
1.2	23.26 %	21.70 %	20.59%	4.49%		
1.5	18.95 %	20.90 %	16.57%	4.16%	8.49%	
2	13.51 %	13.90 %	12.31%	3.93%	6.75%	
2.5	8.12 %	8.00 %	9.07%			
3	6.93 %	3.30 %	11.94%	4.04%	3.80%	
3.5	5.39 %		4.17%	2.47%	2.71%	
4	3.70 %	1.90 %	3.49%	2.02%	2.19%	
4.5	2.79 %		2.61%		1.59%	
5	1.81 %	1.20 %	1.87%	1.46%	1.25%	
5.5	0.66 %		1.37%		0.92%	
6	0.24 %	0.70 %	0.99%	0.90%	0.71%	
6.5	0.17 %		0.75%		0.59%	
7	0.00 %	0.40 %	0.54%	0.56%	0.45%	
7.5	0.00 %		0.34%		0.38%	
8	0.00 %	0.20 %	0.02%	0.22%	0.30%	
8.5			0.11%	0.11%	0.25%	
9	0.10 %		0.07%		0.20%	
9.5			0.04%			
10	0.10 %			0.03%		
11	0.08 %					

Appendix 7: Dartmouth Chlorophyll-a Concentrations

Date	Location	Chl-a Concentration
02-Sep-03	Dart Dam Dart Arm	1.32 µg/L
28-Oct-03	Dart Dam Dart Arm	2.88 µg/L
13-Nov-03	Dart Dam Dart Arm	1.07 µg/L
12-Jan-04	Dart Dam Dart Arm	1.04 µg/L
23-Feb-04	Dart Dam Dart Arm	0.42 µg/L
02-Sep-03	Dart Dam Limnology	0.56 µg/L
13-Nov-03	Dart Dam Limnology	1.22 µg/L
12-Jan-04	Dart Dam Limnology	0.78 µg/L
23-Feb-04	Dart Dam Limnology	1.73 µg/L
02-Sep-03	Dart Dam Mitta Arm	3.55 µg/L
28-Oct-03	Dart Dam Mitta Arm	2.14 µg/L
13-Nov-03	Dart Dam Mitta Arm	1.81 µg/L
12-Jan-04	Dart Dam Mitta Arm	3.94 µg/L
23-Feb-04	Dart Dam Mitta Arm	0.86 µg/L

Appendix 8: Dartmouth Water Quality

Date	Location	Dissolved Oxygen	Temp	Do (% Sat)	Turbidity	pH	Conductivity
25-Jul-03	Big River	12.47 mg/L	4.4 °C	96.1%	32 NTU	6.05 - 6.16	0.036 ms/cm
06-Sep-03	Big River	9.95 mg/L	6.8 °C	81.6%	55 NTU	6.86 - 7.03	0.016 ms/cm
27-Oct-03	Big River	10.30 mg/L	9.0 °C	89.1%	3 NTU	7.1 - 7.2	0.014 ms/cm
14-Nov-03	Big River	8.51 mg/L	12.4 °C	79.7%	1 NTU	7.22 - 7.29	0.013 ms/cm
13-Jan-04	Big River	6.91 mg/L	14.5 °C	67.8%	4 NTU	6.99 - 7.12	0.015 ms/cm
28-Jul-03	Dart River	11.96 mg/L	6.7 °C	97.8%	55 NTU	6.14 - 6.22	0.056 ms/cm
02-Sep-03	Dart River	11.34 mg/L	5.4 °C	89.7%	10 NTU	7.89 - 8.01	0.031 ms/cm
28-Oct-03	Dart River	9.83 mg/L	9.9 °C	86.9%	7 NTU	6.72 - 6.75	0.035 ms/cm
13-Nov-03	Dart River	8.28 mg/L	18.0 °C	87.5%	9 NTU	7.86 - 7.98	0.035 ms/cm
12-Jan-04	Dart River	9.12 mg/L	14.5 °C	89.5%	10 NTU	7.33 - 7.36	0.034 ms/cm
25-Jul-03	Hinnomunjie Bridge	12.90 mg/L	4.4 °C	99.4%	74 NTU	6.04 - 6.12	0.042 ms/cm
06-Sep-03	Hinnomunjie Bridge	9.83 mg/L	7.3 °C	81.6%	4 NTU	6.76 - 7.17	0.027 ms/cm
27-Oct-03	Hinnomunjie Bridge	10.65 mg/L	9.1 °C	92.4%	6 NTU	7.33 - 7.41	0.033 ms/cm
14-Nov-03	Hinnomunjie Bridge	8.15 mg/L	16.4 °C	83.3%	1 NTU	7.39 - 7.44	0.021 ms/cm
13-Jan-04	Hinnomunjie Bridge	6.74 mg/L	19.7 °C	73.7%	5 NTU	6.91 - 7.42	0.025 ms/cm

Date	Depth	Location	Dissolved Oxygen	Temp	Do (%Sat)	Turbidity	pH	Conductivity
28-Jul-03	431.97	Limnology	4.85 mg/L	8.6 °C	41.6%		6.52 - 6.57	0.044 mS/cm
28-Jul-03	422.97	Limnology	4.77 mg/L	8.6 °C	40.9%		6.53 - 6.58	0.045 mS/cm
02-Sep-03	437.44	Limnology	5.99 mg/L	8.5 °C	51.2%		6.92 - 6.99	0.044 mS/cm
02-Sep-03	422.44	Limnology	5.61 mg/L	8.4 °C	47.8%	9 NTU	7.16 - 7.3	0.044 mS/cm
28-Oct-03	444.13	Limnology	8.79 mg/L	13.5 °C	84.4%	5 NTU	6.9 - 6.98	0.042 mS/cm
12-Jan-04	448.16	Limnology					6.31 - 6.31	0.037 mS/cm
12-Jan-04	443.16	Limnology						0.037 mS/cm
28-Jul-03	431.97	Mitta Arm	7.21 mg/L	8.9 °C	63.7%	4 NTU	6.6 - 6.76	0.045 ms/cm
28-Jul-03	422.97	Mitta Arm	9.83 mg/L	7.0 °C	82.9%		6.7 - 6.91	0.048 ms/cm
02-Sep-03	437.44	Mitta Arm	8.69 mg/L	9.3 °C	77.5%		7.05 - 7.16	0.044 ms/cm
02-Sep-03	422.44	Mitta Arm	7.30 mg/L	8.6 °C	64.0%	7 NTU	6.96 - 7.1	0.044 ms/cm
28-Oct-03	444.97	Mitta Arm	9.06 mg/L	14.3 °C	90.5%	4 NTU	6.85 - 6.9	0.041 ms/cm
28-Oct-03	439.97	Mitta Arm	8.87 mg/L	13.7 °C	87.4%	3 NTU	6.99 - 7	0.041 ms/cm
13-Nov-03	445.44	Mitta Arm	8.68 mg/L	20.8 °C	99.1%	2 NTU	8.31 - 8.39	0.039 ms/cm
13-Nov-03	440.44	Mitta Arm	8.75 mg/L	17.2 °C	92.9%	3 NTU	7.98 - 8.27	0.040 ms/cm
12-Jan-04	448.16	Mitta Arm	7.71 mg/L	22.1 °C	90.2%	2 NTU	7.76 - 7.83	0.037 ms/cm
12-Jan-04	443.16	Mitta Arm	7.05 mg/L	21.6 °C	81.7%	3 NTU	7.24 - 7.41	0.037 ms/cm
28-Jul-03	422.97	Dart Arm	6.11 mg/L	8.7 °C	53.7%	4 NTU	6.51 - 6.66	0.043 ms/cm
02-Sep-03	437.44	Dart Arm	7.86 mg/L	8.7 °C	69.1%	5 NTU	6.76 - 6.83	0.043 ms/cm
02-Sep-03	422.44	Dart Arm	7.72 mg/L	8.5 °C	67.6%	5 NTU	6.83 - 6.9	0.043 ms/cm
28-Oct-03	444.13	Dart Arm	8.72 mg/L	14.7 °C	87.9%	4 NTU	7.23 - 7.28	0.042 ms/cm
28-Oct-03	439.13	Dart Arm	9.05 mg/L	13.6 °C	89.0%	4 NTU	7.13 - 7.24	0.042 ms/cm
13-Nov-03	445.44	Dart Arm	8.41 mg/L	21.8 °C	97.9%	8 NTU	8.34 - 8.46	0.042 ms/cm
13-Nov-03	440.44	Dart Arm	8.12 mg/L	16.2 °C	84.5%	4 NTU	7.84 - 8.23	0.042 ms/cm
12-Jan-04	448.16	Dart Arm	8.16 mg/L	22.4 °C	96.0%	5 NTU	7.84 - 7.92	0.037 ms/cm
12-Jan-04	443.16	Dart Arm	7.57 mg/L	22.1 °C	88.6%	3 NTU	7.14 - 7.2	0.037 ms/cm

Appendix 9: DARTMOUTH %DO/TEMPERATURE-Limnology Site

28-Jul-03			02-Sep-03			13-Nov-03 ²⁷			12-Jan-04		
AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)
431.97	54	9.3	448.16	101	23.6	437.44	84	Temperature Probe not functioning	445.44	101	18.7
430.97	51	9.2	447.16	101	22.7	436.44	83		444.44	100	18.5
429.97	51	9.2	446.16	97	22.5	435.44	82		443.44	103	18
428.97	50	9.2	445.16	100	22.4	434.44	82		442.44	102	17.9
427.97	49	9.2	444.16	100	22.3	433.44	82		441.44	102	17.8
426.97	48	9.2	443.16	101	22.1	432.44	81		440.44	102	16.5
425.97	49	9.2	442.16	101	22.1	431.44	80		439.44	102	16.4
424.97	49	9.2	441.16	100	22	430.44	78		438.44	101	15.7
423.97	50	9.2	440.16	100	21.8	429.44	78		437.44	100	14.4
422.97	50	9.2	439.16	99	21.7	428.44	78		436.44	101	13.5
421.97	50	9.2	438.16	99	21.7	427.44	80		435.44	101	12.4
419.97	49	9.1	437.16	97	21.6	426.44	80		433.44	100	12
417.97	49	9.1	436.16	87	19.8	425.44	80		431.44	98	11.1
415.97	49	9.1	435.16	78	18.1	424.44	79		429.44	95	10.9
413.97	49	9.1	434.16	81	16	423.44	79		427.44	93	10.3
411.97	49	9.1	433.16	79	15.1	422.44	78		425.44	85	9.9
409.97	47	9.1	432.16	82	13.9	421.44	77		423.44	83	9.4
407.97	48	9.1	431.16	85	12.9	420.44	77		421.44	76	9.3
405.97	47	9.1	430.16	85	12.6	419.44	77		419.44	74	9.2
403.97	47	9.1	429.16	83	12.2	418.44	77		417.44	68	9.1
401.97	46	9.1	428.16	85	12.2	417.44	77		415.44	66	9.1
399.97	46	9.1	426.16	85	11.4	415.44	75		413.44	63	9
397.97	46	9.1	424.16	85	11	413.44	73		411.44	60	9
395.97	45	9.1	422.16	80	10.7	411.44	71		409.44	54	8.8
393.97	32	9.1	420.16	77	10.5	409.44	70		407.44	51	8.8
391.97	28	9.1	418.16	65	10.3	407.44	70		405.44	47	8.7
389.97	11	9.1	416.16	61	10.2	405.44	69		403.44	46	8.7
387.97	4	9.1	414.16	61	10.1	403.44	70		401.44	44	8.7
385.97	3	9	412.16	61	10.1	401.44	67		399.44	43	8.7
383.97	3	9	410.16	56	10.1	399.44	67		397.44	41	8.6
381.97	3	9	408.16	53	10	397.44	69		395.44	37	8.5
376.97	3	9	406.16	49	10	395.44	69		393.44	37	8.5
371.97	3	9	404.16	47	9.9	393.44	67		391.44	35	8.4
366.97	2	9	402.16	45	10	391.44	68		389.44	35	8.4
361.97	2	9	400.16	42	10	389.44	67		387.44	37	8.3
356.97	2	9	398.16	41	10	387.44	64		385.44	39	8.3
351.97	2	9	396.16	41	10	385.44	62		383.44	42	8.2
346.97	2	9	394.16	40	9.9	383.44	36		381.44	43	8.1
341.97	2	9	392.16	40	9.9	381.44	35		379.44	49	8
336.97	2	9	390.16	38	9.8	379.44	55		377.44	50	8
331.97	2	9	388.16	38	9.9	377.44	72		375.44	56	7.9

²⁷ Data care of Goulburn Murray Water

APPENDIX 9: DARTMOUTH %DO/TEMPERATURE-Limnology Site Con't

28-Jul-03			02-Sep-03			13-Nov-03 ²⁸			12-Jan-04		
AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)
326.97	2	9	386.16	39	9.8	375.44	77		373.44	56	7.9
321.97	2	9	384.16	40	9.8	373.44	82		371.44	56	7.8
			382.16	43	9.8	371.44	86		369.44	58	7.8
			380.16	45	9.8	369.44	86		367.44	58	7.8
			378.16	47	9.8	367.44	90		365.44	58	7.8
			373.16	52	9.7	365.44	92		363.44	58	7.7
			368.16	55	9.8	363.44	93		361.44	58	7.7
			363.16	56	9.7	361.44	99		359.44	60	7.7
			358.16	57	9.8	359.44	103		357.44	60	7.6
			353.16	56	9.8	357.44	111		355.44	59	7.6
						355.44	113				
						353.44	53				
						351.44	37				
						349.44	34				
						347.44	32				
						345.44	28				
						343.44	27				
						341.44	25				
						339.44	23				
						337.44	22				

²⁸ Data care of Goulburn Murray Water

APPENDIX 10: DARTMOUTH %DO/TEMPERATURE- Mitta River Arm

28-Jul-03			02-Sep-03			28-Oct-03			13-Nov-03 ²⁹			12-Jan-04		
AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)
430.97	77	9.4	437.44	92	10	444.13	100	14.2	445.44	104	20.4	448.16	101	21.5
429.97	77	9.4	436.44	90	9.9	443.13	102	14.1	444.44	103	20.3	447.16	103	21.5
428.97	77	9.4	435.44	88	9.7	442.13	102	14.1	443.44	104	19.9	446.16	103	21.3
427.97	77	9.4	434.44	85	9.5	441.13	102	14	442.44	104	18.1	445.16	101	21.3
426.97	77	9.4	433.44	86	9.5	440.13	101	14.2	441.44	108	17.3	444.16	100	21.3
425.97	79	9.4	432.44	86	9.4	439.13	101	13.9	440.44	104	16.7	443.16	98	21.4
424.97	76	9.4	431.44	85	9.4	438.13	100	13.2	439.44	104	15.7	442.16	100	21.2
423.97	76	9.4	430.44	81	9.3	437.13	98	12.9	438.44	102	14.5	441.16	99	20.7
422.97	75	9.4	429.44	78	9.3	436.13	98	11.8	437.44	101	13.2	440.16	88	20.3
421.97	75	9.4	428.44	78	9.3	435.13	96	11.4	436.44	99	12.6	439.16	79	18.7
419.97	75	9.4	427.44	78	9.3	434.13	96	11.4	435.44	100	12.4	438.16	78	17.3
417.97	75	9.4	426.44	76	9.2	433.13	96	11.2	433.44	98	12	437.16	69	16.1
415.97	75	9.4	425.44	76	9.2	432.13	95	10.9	431.44	98	11.4	436.16	73	15.7
413.97	76	9.4	424.44	76	9.2	431.13	95	10.6	429.44	97	10.8	435.16	77	14.6
411.97	76	9.4	423.44	77	9.2	430.13	95	10.6	427.44	97	10.4	434.16	87	13.7
409.97	76	9.4	422.44	77	9.2	429.13	89	10.3	425.44	94	10	433.16	90	12.9
407.97	76	9.4	421.44	78	9.2	428.13	89	10.3	423.44	94	9.9	432.16	94	12.3
405.97	76	9.4	420.44	78	9.2	427.13	88	10.2	421.44	92	9.6	431.16	95	11.8
403.97	76	9.4	419.44	79	9.2	426.13	88	10.2	419.44	92	9.5	430.16	98	11.6
401.97	72	9.4	418.44	79	9.2	425.13	86	9.9	417.44	89	9.3	429.16	101	11.2
399.97	72	9.4	417.44	80	9.2	424.13	88	9.9	415.44	89	9.2	428.16	100	11.1
398.97	65	9.4	416.44	80	9.2	422.13	81	9.6	413.44	80	9.1	426.16	101	10.6
397.97	48	9.4	415.44	80	9.2	420.13	83	9.6	411.44	80	9.1	424.16	98	10.6
396.97	24	9.2	413.44	80	9.2	418.13	80	9.3	409.44	75	8.9	422.16	92	10.5
395.97	5	9.1	411.44	80	9.2	416.13	71	9.3	407.44	74	8.9	420.16	95	10.3
393.97	3	9.1	409.44	79	9.2	414.13	70	9.1	405.44	72	8.8	418.16	89	10.3
391.97	10	9	407.44	80	9.2	412.13	72	9.1	403.44	72	8.9	416.16	91	10.2
386.97	87	8.4	405.44	78	9.2	410.13	75	9.1	401.44	67	8.7	414.16	85	10.2
381.97	83	8.1	403.44	78	9.2	408.13	69	9	399.44	68	8.7	412.16	77	10.1
376.97	3	8.1	401.44	80	9.2	406.13	66	8.8	397.44	68	8.7	410.16	81	10.1
			399.44	80	9.2	404.13	66	8.8	395.44	74	8.7	408.16	77	10.1
			397.44	79	9.2	402.13	64	8.7	390.44	82	8.7	406.16	78	10.1
			395.44	81	9.1	400.13	65	8.7				404.16	74	10.1
			393.44	81	8.7	398.13	70	8.6				402.16	69	10.1
			391.44	100	8.4	396.13	72	8.7				400.16	71	10.3
			390.44	106	8.3	394.13	75	8.5				398.16	70	10.3
			389.44	104	8.2	392.13	81	8.5				396.16	68	10.4
			387.44	106	8.1	390.13	82	8.4				393.16	68	10.3
			385.44	107	8.1	388.13	85	8.3				388.16	68	10.4
			383.44	107	8.2	386.13	86	8.3						
			382.44	99	8.1	384.13	85	8.2						
			381.44	3.4	8.1									

²⁹ Data care of Goulburn Murray Water

APPENDIX 11: DARTMOUTH %DO/TEMPERATURE- Dart River Arm

28-Jul-03			02-Sep-03			28-Oct-03			13-Nov-03 ³⁰			12-Jan-04		
AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)	AHD (m)	DO (% Sat.)	Temp. (°C)
431.97	67	9.4	437.44	91	9.4	444.13	102	14.6	445.44	101	21.5	448.16	103	19.6
430.97	64	9.3	436.44	85	9.4	443.13	103	14.5	444.44	100	21.4	447.16	103	19.5
429.97	64	9.4	435.44	86	9.4	442.13	104	14.6	443.44	100	19.9	446.16	102	19.5
428.97	62	9.3	434.44	85	9.3	441.13	101	14.5	442.44	104	17.8	445.16	96	19.5
427.97	62	9.3	433.44	83	9.3	440.13	102	14.3	441.44	104	16.9	444.16	98	19.3
426.97	62	9.3	432.44	83	9.3	439.13	105	13.4	440.44	102	15.8	443.16	93	19.5
425.97	62	9.3	431.44	84	9.3	438.13	100	13.1	439.44	102	14.9	442.16	98	19.3
424.97	61	9.3	430.44	84	9.3	437.13	101	13	438.44	103	14.6	441.16	93	19.2
423.97	61	9.3	429.44	80	9.3	436.13	98	12.5	437.44	104	14.4	440.16	83	18.7
422.97	60	9.3	428.44	80	9.3	435.13	98	12.1	436.44	98	13.1	439.16	75	17.7
421.97	60	9.3	427.44	85	9.3	434.13	94	11.6	435.44	99	12.4	438.16	76	17.6
419.97	60	9.3	426.44	84	9.3	433.13	93	11.4	433.44	98	11.9	437.16	77	16.9
417.97	59	9.3	425.44	83	9.3	432.13	91	11	431.44	96	11	436.16	78	16.1
415.97	60	9.3	424.44	82	9.3	431.13	93	10.9	429.44	91	10.5	435.16	78	14.9
413.97	60	9.3	423.44	81	9.3	430.13	91	10.7	427.44	90	10.2	434.16	79	14.2
411.97	59	9.3	422.44	76	9.2	429.13	92	10.7	425.44	87	9.9	433.16	80	13.3
409.97	58	9.3	421.44	77	9.2	428.13	89	10.5	423.44	84	9.7	432.16	84	12.6
407.97	59	9.3	420.44	72	9.2	427.13	89	10.3	421.44	77	9.4	431.16	84	11.4
405.97	59	9.3	419.44	71	9.2	426.13	86	10.2	419.44	77	9.2	430.16	85	10.8
404.97	47	9.3	418.44	71	9.2	425.13	85	10	417.44	70	9.1	429.16	84	10.8
403.97	10	9.3	417.44	62	9.2	424.13	82	9.8	415.44	69	9.1	428.16	91	10.3
401.97	4	9.2	416.44	58	9.2	422.13	81	9.8	413.44	62	9	426.16	86	9.8
399.97	3	9.2	415.44	53	9.2	420.13	75	9.5	411.44	62	9	424.16	88	9.3
397.97	3	9.2	414.44	52	9.2	418.13	73	9.4	409.44	56	8.8	422.16	87	9.1
			413.44	51	9.2	416.13	63	9.1	407.44	49	8.8	420.16	82	8.9
			412.44	35	9.1	414.13	64	9.1	405.44	46	8.7	418.16	79	9.1
			411.44	48	9.1	412.13	60	9	403.44	46	8.8	416.16	75	8.8
			410.44	47	9.2	410.13	60	9	401.44	40	8.7	414.16	71	8.9
			409.44	52	9.1	408.13	55	8.9				412.16	71	8.7
			408.44	46	9.1	406.13	52	8.9				410.16	66	8.7
			407.44	41	9.1	404.13	48	8.8				408.16	63	8.7
			405.44	37	9.1	402.13	48	8.8				406.16	61	8.7
			403.44	33	9.1	400.13	42	8.7				404.16	51	8.7
			401.44	26	9.1	398.13	14	8.7				402.16	51	8.7
			399.44	15	9.1	396.13	12	8.7				400.16	50	8.7
			397.44	7	9	394.13	9	8.7				398.16	50	8.7
			395.44	5	9	392.13	8	8.7						
			393.44	5	9	390.13	0	8.7						
			391.44	5	9	388.13	0	8.7						

³⁰ Data care of Goulburn Murray Water

			389.44	4	9	386.13	0	8.7						
			387.44	4	9	384.13	0	8.7						

Appendix 12: Mitta Mitta River Hinnomunjie Bridge Autosampler Data

Location	A/S Date/Time	A/S Height	Total Nitrogen	Total Phosphorus
Hinnomunjie Bridge	23/07/2003 18:15	1.212	11.50 mg/L	1775 µg/L
Hinnomunjie Bridge	23/07/2003 19:00	1.344	5.45 mg/L	785 µg/L
Hinnomunjie Bridge	23/07/2003 19:30	1.444	3.74 mg/L	605 µg/L
Hinnomunjie Bridge	23/07/2003 20:00	1.506	4.45 mg/L	813 µg/L
Hinnomunjie Bridge	23/07/2003 20:45	1.645	10.36 mg/L	1685 µg/L
Hinnomunjie Bridge	24/07/2003 1:45	2.63	20.77 mg/L	8365 µg/L
Hinnomunjie Bridge	24/07/2003 4:45	2.589	14.41 mg/L	3220 µg/L
Hinnomunjie Bridge	24/07/2003 5:15	2.47	17.10 mg/L	3585 µg/L
Hinnomunjie Bridge	24/07/2003 6:30	2.395	20.12 mg/L	4395 µg/L
Hinnomunjie Bridge	24/07/2003 7:45	2.257	10.10 mg/L	2110 µg/L
Hinnomunjie Bridge	24/07/2003 11:15	1.998	5.30 mg/L	950 µg/L
Hinnomunjie Bridge	24/07/2003 14:30	1.889	5.19 mg/L	735 µg/L
Hinnomunjie Bridge	24/07/2003 20:45	1.777	3.03 mg/L	390 µg/L
Hinnomunjie Bridge	25/07/2003 3:15	1.698	2.54 mg/L	335 µg/L
Hinnomunjie Bridge	24/08/2003 5:46	1.705	20.88 mg/L	2389 µg/L
Hinnomunjie Bridge	24/08/2003 6:30	1.753	18.88 mg/L	2802 µg/L
Hinnomunjie Bridge	24/08/2003 7:45	1.864	1.48 mg/L	207 µg/L
Hinnomunjie Bridge	24/08/2003 13:15	1.961	1.34 mg/L	195 µg/L
Hinnomunjie Bridge	24/08/2003 17:15	1.945	21.56 mg/L	3329 µg/L
Hinnomunjie Bridge	24/08/2003 23:30	1.839	1.50 mg/L	159 µg/L
Hinnomunjie Bridge	25/08/2003 2:30	1.797	1.44 mg/L	116 µg/L
Hinnomunjie Bridge	25/08/2003 9:00	1.691	1.27 mg/L	72 µg/L

Appendix 13: Tambo River Nutrients

Date	Depth (m)	Location	Total Nitrogen	Nitrite/Nitrate	Ammonia	Total Phosphorus	Filterable Reactive Phosphorus
07-Sep-03		Morrass Creek (Control)	0.263 mg/L	70 µg/L	9 µg/L	14 µg/L	6 µg/L
26-Oct-03		Morrass Creek (Control)	0.815 mg/L	138 µg/L	15 µg/L	73 µg/L	19 µg/L
14-Nov-03		Morrass Creek (Control)	0.286 mg/L	7 µg/L	10 µg/L	15 µg/L	4 µg/L
10-Dec-03		Morrass Creek (Control)	0.321 mg/L	10 µg/L	14 µg/L	26 µg/L	8 µg/L
13-Jan-04		Morrass Creek (Control)	0.397 mg/L	5 µg/L	9 µg/L	23 µg/L	5 µg/L
07-Sep-03		@Smiths Creek	0.505 mg/L	182 µg/L	18 µg/L	61 µg/L	32 µg/L
27-Oct-03		@Smiths Creek	0.640 mg/L	199 µg/L	10 µg/L	72 µg/L	32 µg/L
14-Nov-03		@Smiths Creek	0.299 mg/L	46 µg/L	7 µg/L	54 µg/L	38 µg/L
10-Dec-03		@Smiths Creek	0.313 mg/L	28 µg/L	8 µg/L	52 µg/L	30 µg/L
13-Jan-04		@Smiths Creek	0.180 mg/L	3 µg/L	4 µg/L	44 µg/L	31 µg/L
25-Jul-03		@Swifts Creek	1.579 mg/L	970 µg/L	65 µg/L	144 µg/L	35 µg/L
07-Sep-03		@Swifts Creek	0.420 mg/L	213 µg/L	5 µg/L	28 µg/L	8 µg/L
26-Oct-03		@Swifts Creek	0.964 mg/L	212 µg/L	13 µg/L	91 µg/L	16 µg/L
14-Nov-03		@Swifts Creek	0.248 mg/L	4 µg/L	10 µg/L	16 µg/L	5 µg/L
10-Dec-03		@Swifts Creek	0.757 mg/L	113 µg/L	33 µg/L	43 µg/L	16 µg/L
13-Jan-04		@Swifts Creek	0.361 mg/L	2 µg/L	13 µg/L	25 µg/L	8 µg/L
07-Sep-03		@Ramrod Creek	0.482 mg/L	147 µg/L	5 µg/L	24 µg/L	4 µg/L
26-Oct-03		@Ramrod Creek	0.244 mg/L	6 µg/L	12 µg/L	13 µg/L	6 µg/L
14-Nov-03		@Ramrod Creek	0.225 mg/L	5 µg/L	6 µg/L	9 µg/L	1 µg/L
10-Dec-03		@Ramrod Creek	1.048 mg/L	303 µg/L	38 µg/L	111 µg/L	10 µg/L
07-Sep-03	0	@ Johnsonville	0.194 mg/L	22 µg/L	17 µg/L	14 µg/L	4 µg/L
07-Sep-03	4	@ Johnsonville	0.432 mg/L	5 µg/L	18 µg/L	34 µg/L	6 µg/L
26-Oct-03	0	@ Johnsonville	0.370 mg/L	5 µg/L	19 µg/L	19 µg/L	6 µg/L
14-Nov-03	0	@ Johnsonville	0.200 mg/L	3 µg/L	8 µg/L	16 µg/L	8 µg/L
14-Nov-03	2	@ Johnsonville	0.328 mg/L	3 µg/L	10 µg/L	17 µg/L	12 µg/L
14-Nov-03	4	@ Johnsonville	0.301 mg/L	4 µg/L	15 µg/L	18 µg/L	9 µg/L
09-Dec-03	0	@ Johnsonville	1.227 mg/L	52 µg/L	30 µg/L	73 µg/L	8 µg/L
09-Dec-03	2	@ Johnsonville	0.355 mg/L	7 µg/L	35 µg/L	23 µg/L	18 µg/L
09-Dec-03	4	@ Johnsonville	0.365 mg/L	8 µg/L	35 µg/L	23 µg/L	26 µg/L
14-Jan-04	0	@ Johnsonville	0.360 mg/L	2 µg/L	7 µg/L	58 µg/L	11 µg/L
14-Jan-04	2	@ Johnsonville	0.525 mg/L	4 µg/L	14 µg/L	59 µg/L	16 µg/L
14-Jan-04	4	@ Johnsonville	0.584 mg/L	3 µg/L	14 µg/L	62 µg/L	19 µg/L

Appendix 14: Tambo River Total Suspended Solids and Total Organic Carbon

Date	Depth (m)	Location	Total Suspended Solids	Total Organic Carbon
07-Sep-03		Morrass Creek (Control)	0.8 mg/L	
26-Oct-03		Morrass Creek (Control)	28.73 mg/L	15.98 mg/L
14-Nov-03		Morrass Creek (Control)		11.00 mg/L
10-Dec-03		Morrass Creek (Control)	1.33 mg/L	
13-Jan-04		Morrass Creek (Control)	0.5 mg/L	
07-Sep-03		@Smiths Creek	2.20 mg/L	5.6 mg/L
27-Oct-03		@Smiths Creek	4.82 mg/L	14.73 mg/L
14-Nov-03		@Smiths Creek		7.7 mg/L
10-Dec-03		@Smiths Creek	2.31 mg/L	
13-Jan-04		@Smiths Creek	<0.5mg/L	
25-Jul-03		@Swifts Creek	112.33 mg/L	8.4 mg/L
07-Sep-03		@Swifts Creek	8.40 mg/L	4.3 mg/L
26-Oct-03		@Swifts Creek	36.79 mg/L	11.49 mg/L
14-Nov-03		@Swifts Creek		9.80 mg/L
10-Dec-03		@Swifts Creek	39.59 mg/L	
13-Jan-04		@Swifts Creek	5.00 mg/L	
07-Sep-03		@Ramrod Creek	6.60 mg/L	6.3 mg/L
26-Oct-03		@Ramrod Creek	1.57 mg/L	6.4 mg/L
14-Nov-03		@Ramrod Creek		
10-Dec-03		@Ramrod Creek	157.25 mg/L	7.9 mg/L
07-Sep-03	0	@ Johnsonville	5.8 mg/L	4.6 mg/L
07-Sep-03	2	@ Johnsonville	4.8 mg/L	3.8 mg/L
07-Sep-03	4	@ Johnsonville	11.20 mg/L	
26-Oct-03	0	@ Johnsonville	7.4 mg/L	
15-Nov-03	0	@ Johnsonville		5.4 mg/L
15-Nov-03	2	@ Johnsonville		5.2 mg/L
15-Nov-03	4	@ Johnsonville		5.9 mg/L
10-Dec-03	0	@ Johnsonville	23.71 mg/L	
10-Dec-03	2	@ Johnsonville	4.8 mg/L	
10-Dec-03	4	@ Johnsonville	3.3 mg/L	
14-Jan-04	0	@ Johnsonville	6.0 mg/L	
14-Jan-04	2	@ Johnsonville	6.9 mg/L	
14-Jan-04	4	@ Johnsonville	7.8 mg/L	

Appendix 15: Tambo River Light Profile Johnsonville

%Transmission of Light			
Depth (m)	26-Oct-03	09-Dec-03	14-Jan-04
0	100.00%	100.00%	100.00%
0.2	31.25%		
0.3	29.68%	29.23%	15.59%
0.4	30.35%	14.61%	13.83%
0.5	26.67%	4.25%	13.18%
0.6	25.98%	2.05%	14.47%
0.7	24.28%	1.05%	12.54%
0.8	22.58%	0.66%	11.58%
0.9	21.74%	0.47%	11.09%
1	20.65%	0.38%	10.61%
1.1	17.90%		9.32%
1.2	16.12%		
1.5	14.15%	0.39%	7.56%
2	12.95%	0.31%	6.75%
3	9.83%	0.11%	4.50%
3.5	7.92%	0.22%	3.22%
4	6.28%	0.15%	2.70%

Appendix 16: Tambo River Chlorophyll Concentration Johnsonville

Date	Location	Chl-a Concentration
26-Oct-03	Tambo at Swan Reach	0.62 µg/L
14-Nov-03	Tambo at Swan Reach	1.78 µg/L
09-Dec-03	Tambo at Swan Reach	1.86 µg/L
14-Jan-04	Tambo at Swan Reach	2.38 µg/L
25-Feb-04	Tambo at Swan Reach	1.21 µg/L

Appendix 17: Tambo River Water Quality

Date	Depth	Location	Dissolved Oxygen	Temperature	% DO Saturation	Turbidity	pH	Conductivity	Salinity
07-Sep-03		Morrass Creek	9.23 mg/L	8.7 °C	79.3%	2 NTU	7.76 - 7.84	0.35 ms/cm	
26-Oct-03		Morrass Creek	8.53 mg/L	16.6 °C	87.5%	82 NTU	7.53 - 7.55	0.20 ms/cm	
14-Nov-03		Morrass Creek	6.67 mg/L	18.1 °C	70.6%	0 NTU	8.15 - 8.19	0.30 ms/cm	
10-Dec-03		Morrass Creek	7.78 mg/L	23.0 °C	90.7%	4 NTU		0.24 ms/cm	
13-Jan-04		Morrass Creek		26.0 °C		4 NTU	7.98 - 8.02	0.31 ms/cm	
07-Sep-03		@Smiths Creek	8.98 mg/L	4.4 °C	69.2%	4 NTU	7.09 - 7.16	0.12 ms/cm	
27-Oct-03		@Smiths Creek	9.82 mg/L	8.0 °C	82.9%	7 NTU	7.39 - 7.4	0.09 ms/cm	
14-Nov-03		@Smiths Creek	7.23 mg/L	14.2 °C	70.5%	1 NTU	8.27 - 8.31	0.15 ms/cm	
10-Dec-03		@Smiths Creek	8.34 mg/L	16.3 °C	85.0%	3 NTU	7.25 - 7.74	0.12 ms/cm	
13-Jan-04		@Smiths Creek	8.24 mg/L	20.7 °C	91.9%	2 NTU	8.07 - 8.68	0.13 ms/cm	
25-Jul-03		@Swifts Creek	11.14 mg/L	7.4 °C	92.7%	303 NTU	6.77 - 6.81	0.17 ms/cm	
07-Sep-03		@Swifts Creek	9.17 mg/L	8.2 °C	77.8%	15 NTU	7.42 - 7.45	0.15 ms/cm	
26-Oct-03		@Swifts Creek	8.75 mg/L	15.8 °C	88.3%	80 NTU	7.58 - 7.64	0.09 ms/cm	
14-Nov-03		@Swifts Creek	7.21 mg/L	18.7 °C	77.3%	1 NTU	8.06 - 8.08	0.14 ms/cm	
10-Dec-03		@Swifts Creek	8.12 mg/L	21.3 °C	91.6%	70 NTU	7.95 - 8.02	0.14 ms/cm	
13-Jan-04		@Swifts Creek	7.19 mg/L	24.9 °C	86.8%	9 NTU	7.19 - 7.57	0.13 ms/cm	
07-Sep-03		@Ramrod Creek	9.70 mg/L	9.4 °C	84.7%	11 NTU	7.93 - 8.03	0.14 ms/cm	
26-Oct-03		@Ramrod Creek	9.96 mg/L	17.0 °C	103.1%	5 NTU	7.68 - 7.76	0.12 ms/cm	
14-Nov-03		@Ramrod Creek	8.31 mg/L	21.0 °C	93.2%	1 NTU	8.3 - 8.37	0.13 ms/cm	
10-Dec-03		@Ramrod Creek	7.58 mg/L	25.0 °C	91.7%	337 NTU	8.19 - 8.26	0.11 ms/cm	
07-Sep-03	0	@Johnsonville	9.02 mg/L	11.4°C	83.6%	2 NTU	7.99 - 8.16	33.36ms/cm	2.08%
26-Oct-03	0	@Johnsonville	9.17 mg/L	15.5°C	92.8%	3 NTU	7.6 - 7.7	25.52ms/cm	1.55%
26-Oct-03	2	@Johnsonville	9.06 mg/L	15.6°C	91.9%	2 NTU	7.77 - 7.78	25.76ms/cm	1.57%
26-Oct-03	4	@Johnsonville	6.95 mg/L	16.1°C	71.4%	1 NTU	7.57 - 7.63	31.9ms/cm	1.99%
14-Nov-03	0	@Johnsonville	8.53 mg/L	19.5°C	93.8%	1 NTU	8.43 - 8.46	25.54ms/cm	1.57%
14-Nov-03	2	@Johnsonville	8.51 mg/L	19.2°C	93.1%	1 NTU	8.53 - 8.54	29.06ms/cm	1.80%
14-Nov-03	4	@Johnsonville	7.39 mg/L	18.7°C	80.1%	5 NTU	8.47 - 8.49	30.2ms/cm	1.88%
09-Dec-03	0	@Johnsonville	7.64 mg/L	20.7°C	86.2%	6 NTU	8.44 - 8.47	30.75ms/cm	1.91%
09-Dec-03	2	@Johnsonville	7.96 mg/L	20.3°C	89.1%	2 NTU	8.52 - 8.58	31.55ms/cm	1.97%
09-Dec-03	4	@Johnsonville	6.5 mg/L	20.6°C	73.2%	1 NTU	8.35 - 8.45	32.24ms/cm	2.03%
14-Jan-04	0	@Johnsonville	7.58 mg/L	21.7°C	87.2%	4 NTU	7.28 - 7.38	32.9ms/cm	2.06%
14-Jan-04	2	@Johnsonville	7.5 mg/L	21.8°C	86.5%	3 NTU	7.4 - 7.41	32.9ms/cm	2.07%
14-Jan-04	4	@Johnsonville	6.19 mg/L	21.8°C	71.4%	2 NTU	7.15 - 7.28	33.26ms/cm	2.10%

Appendix 18: Swifts Creek Autosampler

Location	A/S Date/Time	Gauge Height	Total Nitrogen	Total Phosphorus
@Swifts Creek	8/06/2003 12:10	2	2.41 mg/L	123 µg/L
@Swifts Creek	8/06/2003 16:40	2.101	0.91 mg/L	63 µg/L
@Swifts Creek	8/07/2003 3:00	2.1	1.00 mg/L	106 µg/L
@Swifts Creek	8/13/03 10:20 PM	2	0.72 mg/L	65 µg/L
@Swifts Creek	8/14/03 4:00 AM	2.075	0.71 mg/L	52 µg/L
@Swifts Creek	8/14/03 4:10 AM	2.113	0.79 mg/L	78 µg/L
@Swifts Creek	8/19/03 6:10 PM	2.15	1.78 mg/L	92 µg/L
@Swifts Creek	8/20/03 10:00 PM	2.1	17.83 mg/L	900 µg/L
@Swifts Creek	8/24/03 10:20 AM	2.102	0.54 mg/L	41 µg/L
@Swifts Creek	8/24/03 1:30 PM	2.15	0.61 mg/L	32 µg/L
@Swifts Creek	8/24/03 2:10 PM	2.253	0.63 mg/L	49 µg/L
@Swifts Creek	8/24/03 2:40 PM	2.318	1.16 mg/L	53 µg/L
@Swifts Creek	8/24/03 3:10 PM	2.355	1.07 mg/L	59 µg/L
@Swifts Creek	8/24/03 4:10 PM	2.402	20.35 mg/L	1850 µg/L
@Swifts Creek	8/24/03 5:20 PM	2.454	43.28 mg/L	2750 µg/L
@Swifts Creek	8/24/03 6:40 PM	2.504	1.69 mg/L	127 µg/L
@Swifts Creek	8/24/03 8:30 PM	2.606	54.53 mg/L	5125 µg/L
@Swifts Creek	8/24/03 10:00 PM	2.708	56.95 mg/L	8325 µg/L
@Swifts Creek	8/25/03 6:40 AM	2.698	3.27 mg/L	459 µg/L
@Swifts Creek	8/25/03 11:00 AM	2.6	3.18 mg/L	647 µg/L
@Swifts Creek	8/25/03 6:30 PM	2.495	3.78 mg/L	600 µg/L
@Swifts Creek	8/25/03 11:20 PM	2.448	58.30 mg/L	9650 µg/L
@Swifts Creek	8/26/03 8:00 AM	2.4	33.48 mg/L	6050 µg/L
@Swifts Creek	8/26/03 5:00 PM	2.35	36.98 mg/L	5000 µg/L
@Swifts Creek	8/27/03 5:10 AM	2.299	28.73 mg/L	3875 µg/L
@Swifts Creek	8/27/03 9:30 PM	2.25	25.88 mg/L	2850 µg/L
@Swifts Creek	8/30/03 2:00 AM	2.149	0.81 mg/L	65 µg/L
@Swifts Creek	9/02/2003 5:40	2.1	0.57 mg/L	54 µg/L
@Swifts Creek	9/04/2003 9:10	2.05	19.00 mg/L	1025 µg/L
@Swifts Creek	9/08/2003 8:50	2	34.08 mg/L	3900 µg/L