HYDRO ELECTRIC CORPORATION
ABN 048 072 377 158
4 Elizabeth St, Hobart
Tasmania, Australia

Basslink Monitoring Program

Gordon River Basslink Monitoring Annual Report

2001-02

Prepared by

Hydro Tasmania

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Executive Summary

The Gordon River Basslink Monitoring Annual Report is an output from the Gordon River Basslink Monitoring Program being conducted by Hydro Tasmania. The objective of the report is to present the consolidated results of all monitoring undertaken pursuant to the Gordon River Basslink Monitoring Program during the 2001-02 reporting year.

The Gordon River Basslink Monitoring Program for 2001-02 is the first of a three-year pre-Basslink program of monitoring. The program will extend the understanding gained during the 1999-2000 investigative years (see Locher 2001) on the present condition, trends, and spatial and temporal variability of potentially Basslink-affected aspects of the middle Gordon River environment.

The Gordon River Basslink Monitoring Program will obtain long-term data, which will permit more precise quantification of spatial and temporal variability, processes and rates. This information will assist in the future management of the river.

The results from the 2001-02 monitoring are reported in eight sections. Analyses of longer-term trends have not been undertaken because there are presently insufficient data to make such analyses meaningful. Most of the information presented in this document is extracted from field reports produced by the various researchers employed to conduct the monitoring. The efforts of these authors are duly acknowledged.

The requirements of the Gordon River Basslink Monitoring Program were met in 2001-02 and the results of this work have set the groundwork for future years.

Hydrology

The hydrological conditions in the Gordon River are important, both in direct terms and with regard to their effect on the physical and biotic systems of the river. This section discusses the hydrological regimes which prevailed in Lake Gordon, the power station tailrace, and site 44, some 33 km downstream of the power station over the 2001-02 monitoring year.

The hydrological data presented in this report indicate that 2001-02 was a year when the power station operated more than the historic average, but similarly to recent years. This resulted in a significant drawdown of Lake Gordon, to decade-low levels and with the greatest drawdown being in the summer-autumn months of 2002.

Power station operation, and hence tailrace discharge, varied throughout the year. From mid-February to early June 2002 the power station was operating at full gate almost continuously.

Analysis of the discharge pattern at site 44 (Gordon above Franklin) indicated that the discharge at this site matched the power station tailrace discharge pattern closely, with occasional high discharge spikes indicating natural high-volume discharge events originating in tributary streams.

The hydrological data indicated that the power station discharge had a dominating effect on the middle Gordon River, from the power station tailrace to its junction with the Franklin River, which tended to override the natural seasonal discharge pattern. The tributary streams contributed seasonally variable amounts to this flow, as well as peak discharges during major runoff events.

Water Quality

Water quality parameters were measured in Lakes Gordon and Pedder, and in the Gordon River downstream of the power station. Additionally, an investigation into the incidence of gas supersaturation at the power station tailrace was undertaken.

Water column profiles in Lake Gordon showed that thermocline and oxycline development was strongest in autumn and winter, although in the Boyes Basin this was likely to be influenced by the level of inflow to the lake from the upper Gordon River. This was in contrast to the shallower and more exposed waters of Lake Pedder, where no significant stratification was recorded.

Surface water quality in both lakes was similar, with low turbidity and chlorophyll-*a* values, mildly acidic pH, healthy levels of dissolved oxygen and low concentrations of nutrients. A single, relatively high, chlorophyll-*a* reading was recorded at Boyes Basin in Lake Gordon.

The water quality in Lakes Pedder and Gordon is good, and within the range expected for lakes in this region. Water temperature variations at sites downstream of the power station were greatly reduced, both diurnally and seasonally. Low dissolved oxygen in water released from the power station was not perceived as a great risk because it has been shown to reach ambient conditions within 1.5 km of the tailrace. Gas supersaturation was not evident in 2001-02.

Fluvial Geomorphology

The fundamental objective of the Gordon River Basslink geomorphology monitoring program is to document fluvial geomorphic changes to the banks of the middle Gordon River between the power station tailrace and the mouth of the Franklin River, and to relate these changes to power station operations or other factors wherever possible.

Erosion pin and scour chain results indicated that scour of bank toes occurred throughout the study area, although this generally decreased with distance downstream. A notable exception was Zone 1, closest to the power station, where relatively little toe scour was recorded.

Seepage erosion was most active in Zone 2, and decreased in occurrence and magnitude downstream. Erosion pins and scour chains recorded the enlargement of bank cavities and the downslope movement of sandy material. Seepage erosion activity was consistent with peizometer data which showed banks were saturated for much of the monitoring period due to the prolonged use of 3-turbines at the power station.

Karst Geomorphology

Preliminary results suggest that deposition may have occurred in both caves between December 2001 and March 2002. Very limited data from the two original erosion pins installed in September 2000 suggest that there may have been nett deposition in Kayak Kavern and negligible nett sediment change in Bill Neilson Cave.

In the Gordon-Albert dolines there has been no appreciable sediment movement between November 2001 and March 2002.

The water level recorder data show that during the summer months when there was little natural pickup in the catchment, the Gordon River affects the recorder in Bill Neilson cave when the power station is releasing more than approximately 210 cumecs. This suggests that, at least during the summer months, the dry sediment bank located 175 m into the cave is unlikely to be affected by power station operations. The influence of high flows in the Denison River on the system in conjunction with the power station will be assessed when the winter data have been obtained and the recent theodolite survey data have been analysed.

Riparian Vegetation

Riparian vegetation sampling was conducted in Autumn (March-April) 2002. Quadrat studies were conducted at 23 permanent sites along the Gordon, Franklin and Denison Rivers. Photo-monitoring studies will commence in December 2002 and be reported in the 2002-03 Gordon River Basslink Monitoring Annual Report.

Eighty-five plant species were recorded in the quadrat surveys across all rivers. Patterns of species cover and diversity within the Gordon River were consistent with Davidson and Gibbons (2001) who found significant differences in sites of varying bank height on the Gordon River. The results show a large degree of variability within each site as a consequence of the extent of disturbance regime. Species diversity, species overlapping cover and litter cover are all directly proportional to bank height (quadrat location) whilst bare ground and root exposure are inversely proportional.

Recruitment within the Gordon River has not previously been quantified. The diversity and level of recruitment identified in the March-April monitoring was higher at most sites than expected and not confined to the quadrats above high water mark. This suggests that recruitment of some species is not restricted by propagule availability and that conditions suitable for germination do occur. However, the absence of older cohorts casts doubt on the successful establishment of seedlings and more temporal data points are required to confirm any patterns.

Macroinvertebrates

Macroinvertebrates were monitored in spring (October) 2001 and autumn (March) 2002 at nine sites in the Gordon River between the Gordon Power Station and the Franklin River confluence. Six reference sites were monitored in the Franklin, Denison, Maxwell and Jane Rivers at the same time.

Patterns and trends in abundance and diversity and O/E values were similar to those observed in 1995-96 and 1998-99, with:

- Number of taxa and total macroinvertebrate abundance increasing from low levels with distance downstream of the power station;
- O/E values increasing with distance from the power station, with values upstream of the Denison River falling significantly below reference values.
- no statistically significant differences between O/E values for 2001-2002 and 1998-99.

Data collected in this survey will form part of the database used to assess changes in instream conditions associated with changes in flow regimes resulting from Basslink.

Algae

Benthic algae were sampled in spring (October) 2001 and autumn (March) 2002 at nine sites in the Gordon River between the Gordon Power Station and the Franklin River confluence.

Patterns and trends in algal cover were similar between the two seasons, with:

- Aquatic flora having a consistently low to moderate cover across all sites (a grand mean of 10.5% by area for both seasons);
- Moss and filamentous algae having similar, low overall mean % cover across all sites (4-5% of benthic area);
- Mean percent moss and filamentous algal cover being positively correlated;
- Filamentous algae being more abundant at sites 75 (G4) and 74 (G4a) than at other sites;
- Characeous algae being observed only at sites 74 (G4a) and 72 (G5).
- Mean moss cover being highly variable, ranging from 0.2 to 19%.
- Macrophytes occurring only at sites 72 (G5) and 69 (G6), and at low densities.

Fish

Monitoring of the fish populations of the middle Gordon River, its tributaries and out-of-catchment reference sites was conducted during December 2001 and April 2002. Six sites were not visited due to bad weather, high flows or equipment failure at the time of monitoring.

The fish communities of the middle Gordon River remain dominated by brown trout (*Salmo trutta*), particularly in the upstream zones, where they have become well established in all the major tributaries as well as the Gordon River itself. A second exotic species, redfin perch (*Perca fluviatilis*) was detected for the first time in the middle Gordon River.

Numbers and distributional patterns for native species were similar to previous surveys of the Gordon River, with galaxiids being largely restricted to tributaries, and with low numbers of native species in the Gordon River generally. Other patterns initially reported during the Basslink investigations phase are still apparent, including the higher catch rates of eels in the Gordon River compared to the unregulated Franklin River.

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1 The Report and the Program

The Gordon River Basslink Monitoring Annual Report is a primary output from the Gordon River Basslink Monitoring Program being conducted by Hydro Tasmania. The objective of the report is to present the consolidated results of all monitoring undertaken pursuant to the Gordon River Basslink Monitoring Program during 2001-02. The report is to be submitted to the Minister administering the *Water Management Act* 1999 (Tasmania) and the Commonwealth Environment Minister. It will also be made available to the public.

1.1 Origins

The Basslink interconnector will link the Tasmanian electricity grid to that of mainland Australia. This will allow Hydro Tasmania to feed renewable energy into the National Electricity Market in a manner that optimises the utility of hydro-electric generation (i.e. to meet demand peaks), while also facilitating the importation of electricity to Tasmania at other times, as required. Consequently, once Basslink commences, there are likely to be changes to the way the Tasmanian electricity generation system is operated.

Comprehensive modelling and associated studies have been carried out to determine what the effects of these likely changes will be, and how best to mitigate any detrimental effects (Locher 2001). The middle Gordon River downstream of the Gordon Power Station, in the south-west of the state, is the waterway most likely to be affected by the changes resulting from Basslink operations. The discharge from the power station runs through the Tasmanian Wilderness World Heritage Area, to the river mouth at Macquarie Harbour.

Hydro Tasmania commissioned numerous environmental studies in this area to better understand the existing conditions within the regulated reaches of the Gordon River. The results of these studies have been reported in the Basslink Integrated Impact Assessment Statement (IIAS), under the heading, “Potential effects of changes to hydro power generation”.

The Gordon River Basslink Monitoring Program arose from the recommendations of these studies and was endorsed by the Basslink Joint Advisory Panel (Basslink Joint Advisory Panel 2002a). The monitoring program was incorporated into Hydro Tasmania’s Special Water Licence by a Deed of Amendment (Basslink Joint Advisory Panel 2002b). The work carried out in 2001-02 was based on the requirements of the ‘Gordon River Basslink Monitoring Program’ document, which forms Attachment 3 of the draft Deed of Amendment.

1.2 The Monitoring Program

The Gordon River Basslink Monitoring Program for 2001-02 formed the first of a three-year pre-Basslink program of monitoring which aims to extend the knowledge gained during the 1999-2000 investigative years (see Locher 2001) on the middle Gordon River environment.

The Gordon River Basslink Monitoring Program will obtain long-term data which will permit refinement of theories and more precise quantification of spatial and temporal variability, processes and rates. This information will assist in the future management of the river.

1.3 Logistical Considerations

Access presents significant challenges in this part of the Tasmanian Wilderness World Heritage Area. On-site monitoring activities require helicopter support, due to the density of the terrestrial vegetation and the absence of access infrastructure.

Power station shutdowns are needed because the only viable landing sites are on cobble bars in the river bed which are exposed only when there is little or no discharge from the power station. They are also required because most of the biotic and geomorphic monitoring activities require measurements or sampling to take place within the river channel, which would not be possible under conditions of power station discharge.

The Gordon River Basslink Monitoring Program has a schedule of four visits per year, each involving two consecutive days of power station shutdown. These are planned to occur most frequently on weekends when power demand from the Gordon Power Station is lowest. If access is impossible on the planned shutdown weekends, the outage for the Gordon Power Station will be postponed to a subsequent weekend. Co-ordination with the power station maintenance timetable is an essential requirement of the monitoring program.

In 2001-02, the summer (December) fish monitoring was interrupted by poor weather, resulting in it being re-scheduled for the following weekend.

1.4 Document structure

This document is the first of the Gordon River Basslink Monitoring Annual Reports to be produced, and is organised into ten sections and an executive summary.

This first section outlines the origins of the Gordon River Basslink Monitoring Program and discusses the requirements and some of constraints of the program. Sections 2 - 9 report on the monitoring work which was undertaken during 2001-02, and present the consolidated results of each of the individual monitoring elements. These include:

- Hydrology (section 2);
- Water quality (section 3);
- Fluvial geomorphology (section 4);
- Karst geomorphology (section 5);
- Riparian vegetation (section 6);
- Macroinvertebrates (section 7);
- Algae (section 8); and
- Fish (section 9).

Only the results from the 2001-02 monitoring are reported in each of these sections. No analyses of longer-term trends have been undertaken because there are presently insufficient data to make such analyses meaningful. The analysis of variability and time-related trends within the Gordon River ecosystems under study will be reported in the Basslink Baseline Report, which is due to be submitted two months prior to the implementation of Basslink.

Section 10 lists the reference material used in this document.

1.5 Authorship of Field Reports

The information presented in sections 2-9 was extracted from field reports produced by the various researchers employed to conduct the monitoring, as shown in Table 1.1. The efforts, and original contributions, of these authors are duly acknowledged.

Table 1.1. Section numbers, section titles and original authors from whose field reports most of the information in sections 2 – 9 was extracted.

Section	Section title	Author(s)
2	Hydrology:	David Blühdorn and Bryce Graham (Hydro Tasmania)
3	Water quality	Chris Bobbi (Hydro Tasmania)
4	Fluvial geomorphology	Lois Koehnken (consultant) and Helen Locher (Hydro Tasmania)
5	Karst geomorphology	J. Deakin and J. Butt (consultants)
6	Riparian vegetation	Anita Wild (Hydro Tasmania)
7	Macroinvertebrates	Peter Davies and Laurie Cook (consultants)
8	Algae	Peter Davies and Laurie Cook (consultants)
9	Fish	David Andrews and Mick Howland (Hydro Tasmania)

2 Hydrology

The hydrological conditions in the Gordon River are important, both in direct terms and with regard to their effect on the physical and biotic systems of the river. The potential for changed hydrology is the major impact that Basslink might have on the Gordon River, and hence any changes to the current hydrological regime are of prime importance in the analysis of other aspects of the Gordon River environment.

This part of the Gordon River Basslink Monitoring Annual Report summarises the hydrological data from Lake Gordon and the Gordon River downstream of the Gordon Power Station for the 2001-02 period.

2.1 Site Locations

The seven gauging stations used to record river levels during 2001-02 are shown in Figure 2.1. These were sites 39, 44, 62, 69, 71, 75 and the Gordon Power Station. Figure 2.1 also indicates a monitoring location at site 65. This site has yet to be installed.

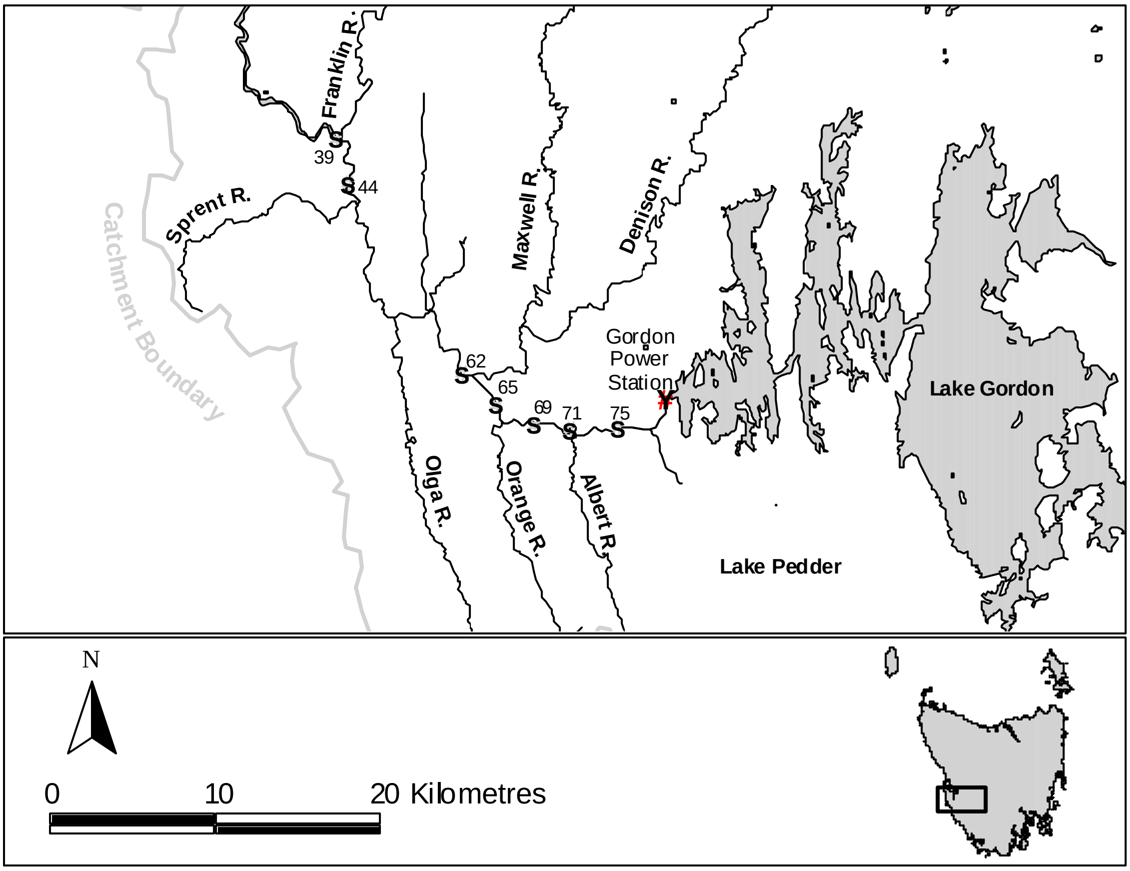


Figure 2.1 Location of the water level recorders in the middle Gordon River.

Data from the power station tailrace and site 44 were analysed for this report. Site 44 is the furthest-downstream site which is not affected by tidal influences. The intermediate sites showed discharges appropriate to their locations in the catchment, but not differing greatly in overall pattern from those recorded at site 44 or the tailrace. Notable differences are the greater influx of natural flows at sites downstream of the Denison River, and a general decrease in the height of river level change (associated with power station operation) with distance downstream.

2.2 Gordon Power Station discharge

2.2.1 Event analyses

One of the methods for analysing power station operations and their effect on discharge into the Gordon River is to examine the number and duration of shutdown (zero discharge) and operating (>zero discharge) events.

In 2001-02, the shutdown events were clustered around the 1-4 hour and 8-9 hour durations, with a further peak at 72 hours. Figure 2.2 shows the frequency and duration of shutdown events for 2001-02. In total, 47 shutdown events were recorded during the year. Most of the 40 to 72 hour events were attributable to the power station outages required for downstream monitoring.

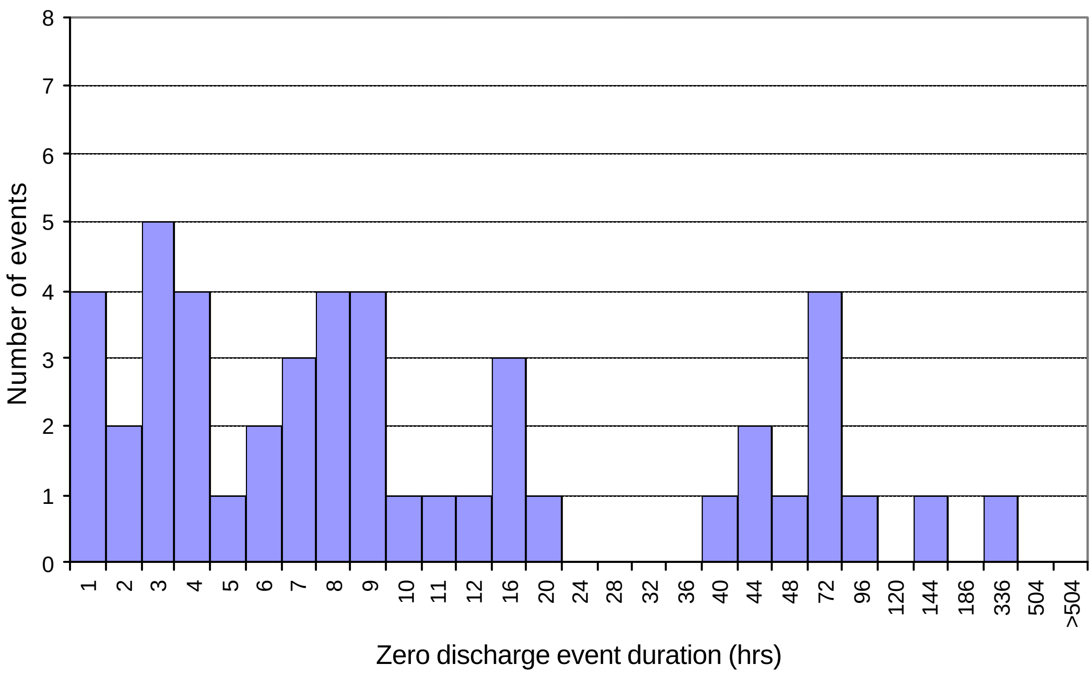


Figure 2.2. Frequency and duration of zero discharge (shutdown) events recorded for the Gordon Power Station during 2001-02.

The number of operating events, indicated by discharges greater than zero cumecs ($m^3.s^{-1}$), is shown in Figure 2.3. This figure indicates that there were a comparatively large number of short (1 hour) events, as well as those of 16, 44, 180, and >504 hours duration. This pattern tends to indicate that the power station was operated for relatively lengthy periods between shutdowns, with some short-duration start-ups.

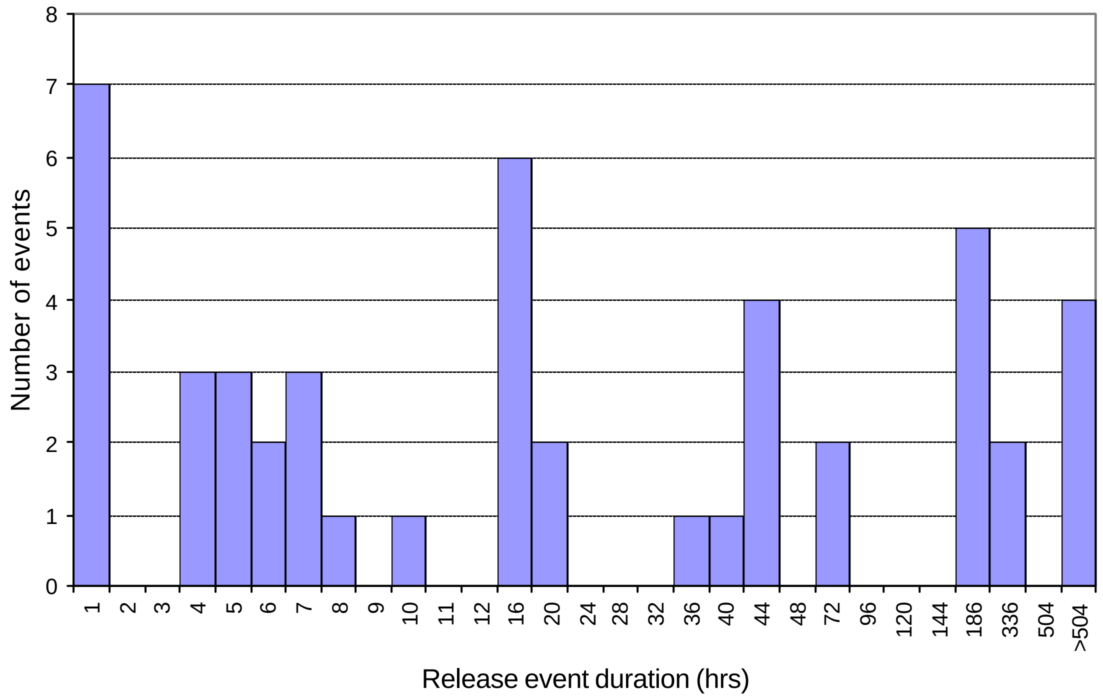


Figure 2.3. Frequency and duration of operating (discharge > zero) events recorded for the Gordon Power Station during 2001-02.

2.2.2 Discharge

Figure 2.4 shows the time series plot for discharge from the power station tailrace. It indicates that, from July to October 2001, the power station was operating at a range of discharges, which frequently varied from full gate (approximately 250 cumecs) to zero. From mid-October to early February, the power station operated at intermediate discharges, while from mid-February to early June 2002 the power station was operating at full gate almost continuously. During June, the pattern reverted to one of intermittent operation.

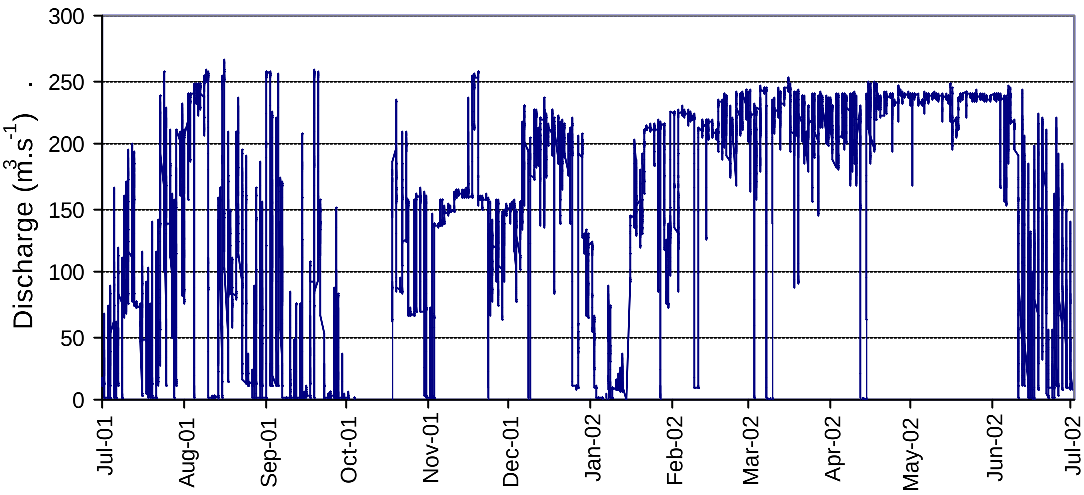


Figure 2.4. Tailrace discharge from the Gordon Power Station during 2001-o2

2.2.3 Median monthly discharge

Figure 2.5 shows the median monthly discharge from the power station for 2001-02 compared with long-term values. This illustrates that the power station has been run on higher loads than has been the historic norm. The power station has been utilized more frequently due to increased power demand, and this trend is likely to continue. Additionally, the Gordon Power Station has been required to make up the loads which stations elsewhere in the state have been unable to provide due to the dry winter of 2001 and the relatively dry autumn of 2002.

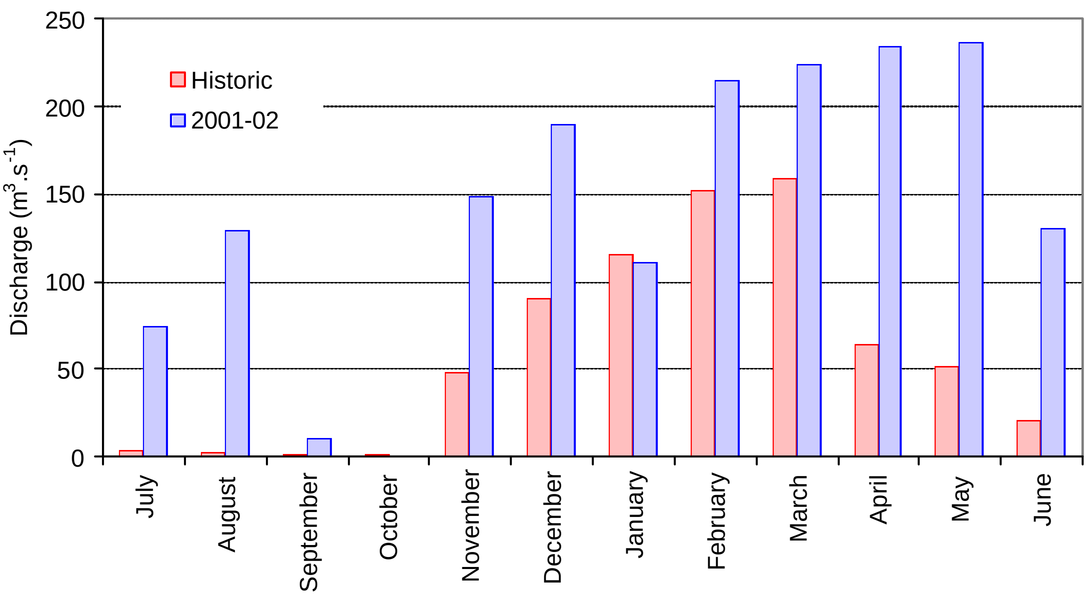


Figure 2.5. Median monthly discharge from the tailrace of the Gordon Power Station for 2001-02.

2.2.4 Duration curves

Figure 2.6 gives the duration curve for the power station tailrace discharge for 2001-02. It shows the characteristic bulges and inflection points associated with the operation of one (80 $m^3.s^{-1}$), two (160 $m^3.s^{-1}$), or three (240 $m^3.s^{-1}$) turbines.

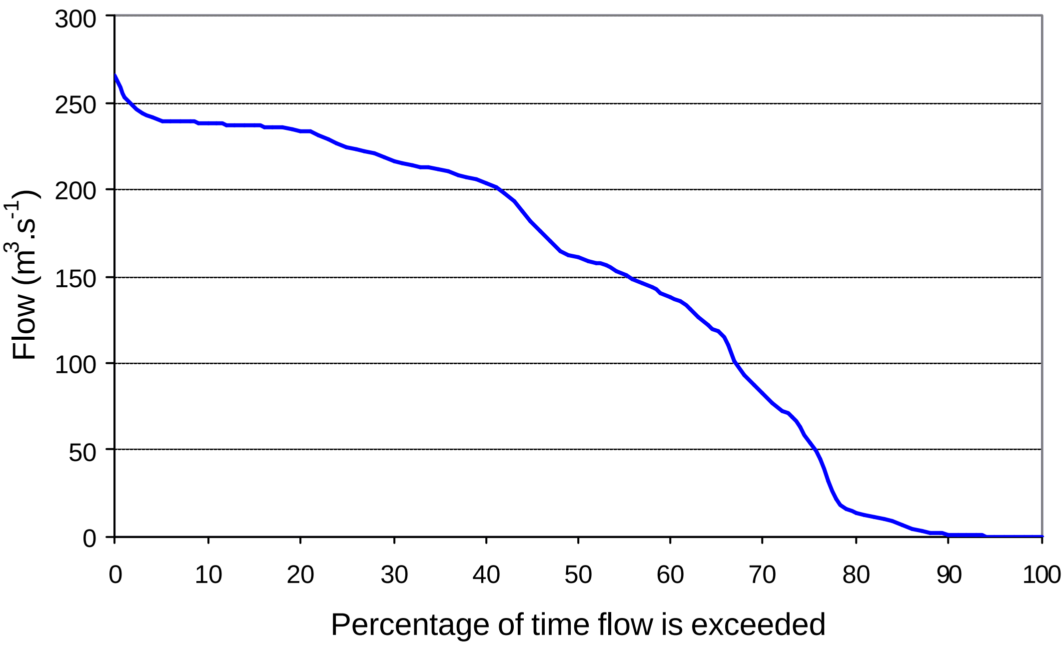


Figure 2.6. Duration curve for discharge from the power station tailrace for 2001-02.

2.3 Gordon River downstream of the power station

A number of stream gauging sites have been established on the Gordon River downstream of the Gordon Power Station (Figure 2.1). The Gordon above Franklin site (site 44) is the furthest downstream site unaffected by tidal influences. Site 44 records the power station discharge following 33 km of flow in the natural stream channel. It also captures the discharge from a number of significant tributaries, including the Albert, Orange, Denison, Olga and Sprent Rivers. It does not include information about flows in the Franklin River. Data from site 44 were used to indicate the effects of tributary streams on the discharge pattern from the power station.

2.3.1 Flow

Figure 2.7 shows the time series plot for flow at site 44 for 2001-02. The power station discharge pattern (see Figure 2.4) remains discernable, especially during the autumn 2002 period. Over this is superimposed the discharge pattern from tributary streams, such as the Denison River, giving the high peak discharges evident in Figure 2.7. Peak flows occurred in August 2001 and June 2002.

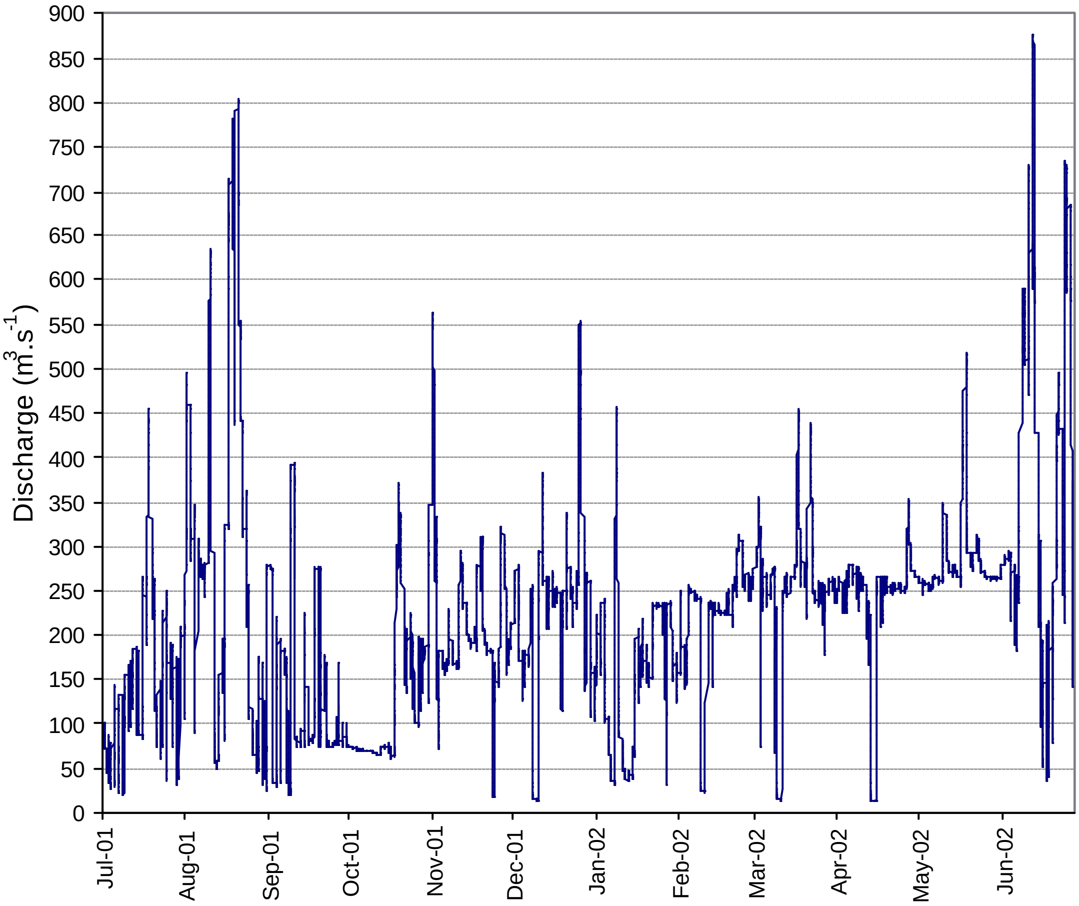


Figure 2.7. Discharge recorded at site 44 (Gordon above Franklin) during 2001-02.

2.3.2 Median monthly flows

The peaks in the discharge data for site 44 (Figure 2.7) are also reflected in the median monthly discharge. Figure 2.8 shows the median monthly discharge for this site as well as the tailrace site. It indicates that substantial natural discharges occurred in August 2001 and June 2002, while the power station discharge tended to dominate the flow pattern from February to May 2002.

2.3.3 Duration curves

Figure 2.9 illustrates the duration curve for Gordon River site 44 (upstream of the Franklin River) and compares it with that of the power station tailrace. It shows the effects of the power station discharge, indicated by the curve's shape, between the 10th and 90th percentiles, matching that of the tailrace. It also shows the effects of natural inflows, indicated by the high discharge values in the <10th percentiles and the elevated discharge from the 90th to the 100th percentiles, as well as providing the additional flow in the 10th to 90th percentile range.

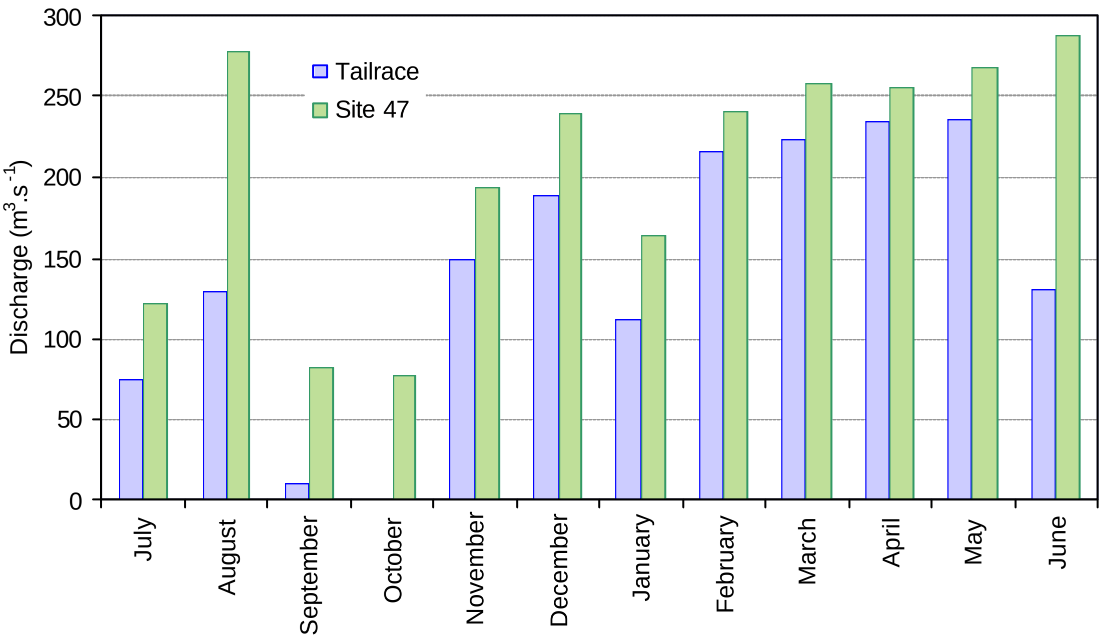


Figure 2.8. Median monthly discharges recorded at site 44 and at the power station tailrace during 2001-02.

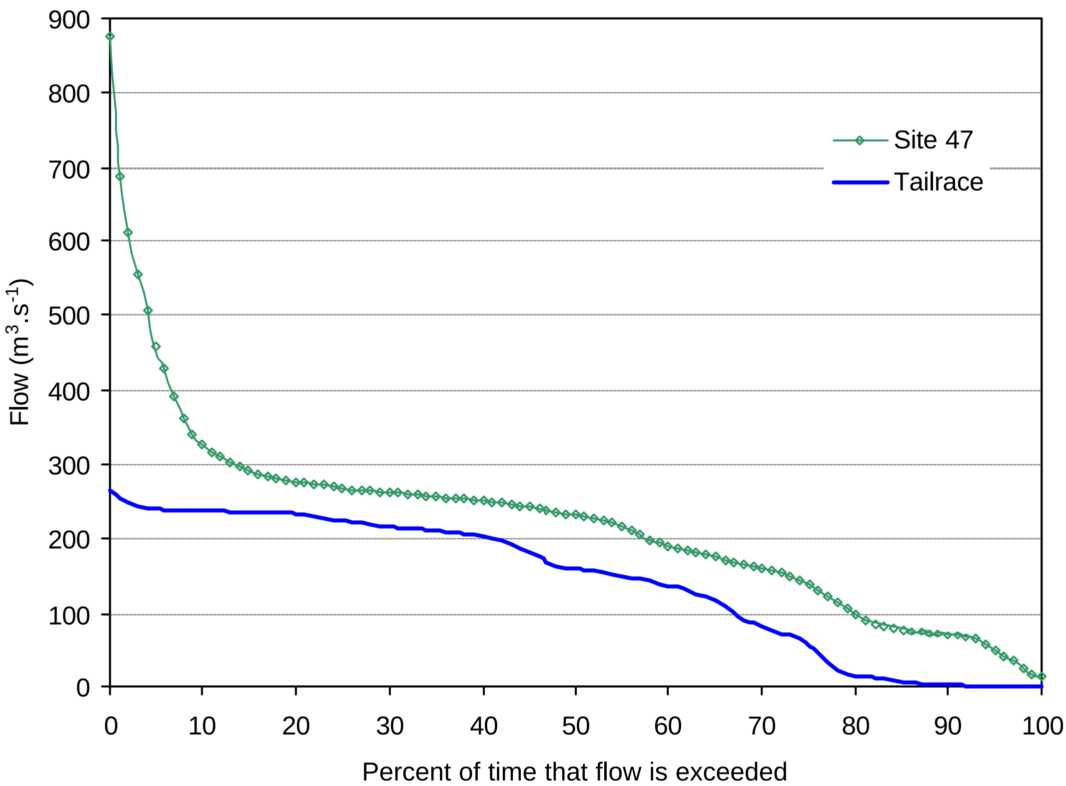


Figure 2.9. Duration curves for the Gordon above Franklin site (site 44) and the Gordon Power Station tailrace site for 2001-02.

2.4 Conclusion

The hydrological data presented in this report indicate that 2001-02 was a year when the power station operated more than usual.

Discharge from the power station reflected this operational pattern. Event analysis indicated that the power station was operated for relatively lengthy periods between shutdowns, with some short-duration start-ups. The power station discharge also showed an alteration to the usual seasonal discharge pattern in that, from mid-February to early June 2002, the power station was operating at full gate almost continuously. The median monthly discharge values show that, in almost every month, the discharge for 2001-02 exceeded the historic value.

Given this high rate of power station usage and generally low tributary flows, it could be expected that downstream sites would be more than usually dominated by power station discharges. The furthest-downstream gauging site that is independent of tidal influences, the Gordon above Franklin (site 44), was used to compare discharge patterns. The data from this site showed that the discharge at site 44 matched the power station tailrace discharge pattern closely, with occasional peaks indicating natural high volume discharge events originating in tributary streams. This pattern was also evident in the median monthly flow pattern, which closely followed that of the tailrace except in August 2001 and June 2002, when high natural discharge events occurred. The duration curve for site 44 also mirrored the tailrace pattern, with the inclusion of flood flows forming the lower percentile values (0 - 10), and more discharge at the higher percentile values (90 - 100).

The hydrological data indicate that the power station discharge had a dominating effect on the flows in the middle Gordon River, from the power station tailrace to its junction with the Franklin River and the commencement of tidal influences on water levels. The tributary streams contributed seasonally variable amounts to this flow, as well as peak flows during major runoff events.

Under natural conditions, late summer and autumn tend to be the times of lowest flows. In 2001-02, these months recorded among the highest median monthly discharge values.

3 Water Quality

Water quality parameters were measured in Lakes Gordon and Pedder, and in the Gordon River downstream of the power station. Additionally, an investigation into the incidence of gas supersaturation at the Gordon Power Station tailrace was undertaken.

3.1 Site Locations and field methods

In the lakes, water samples for nutrient analysis were taken from the surface waters. For each water sample, the following parameters were measured by laboratory analysis:

- total phosphorus and dissolved reactive phosphorus (DRP);
- nitrite, nitrate, total Kjeldahl nitrogen (TKN), ammonia;
- chlorophyll-*a*;
- metals (Fe, Mn, Zn, Cd, Cu, AL, Co, Cr, Ni and Pb);
- sulphate;
- alkalinity; and
- dissolved organic carbon.

Additionally, depth profiles of basic physico-chemical parameters (water temperature, dissolved oxygen, conductivity, pH, and turbidity) were taken at approximately 2m intervals at each of the nominated depth profile sites in Lakes Gordon and Pedder. The water quality monitoring sites are shown in Figure 3.1.

3.1.1 Lake Gordon

During 2001-02, water quality data from Lake Gordon were collected quarterly at the power station intake, at Calder Reach and at Boyes Basin near the upper Gordon River inflow. At all three of these locations, depth profiles of water temperature, dissolved oxygen, pH, and conductivity were taken to characterise stratification of the water column. Depth samples for turbidity were collected only at the power station intake. Surface water chlorophyll-*a*, water temperature, pH, conductivity, turbidity and dissolved oxygen concentration was also recorded at these locations. Surface samples for laboratory measurement of nutrients and metals were collected in Lake Gordon at the power station intake and at Boyes Basin.

3.1.2 Lake Pedder

At Lake Pedder, depth profile data were collected quarterly off Groombridge Point, which is the deepest part of the lake. Surface water samples (chlorophyll-a, water temperature, pH, conductivity, turbidity and dissolved oxygen concentration) were recorded at Groombridge Point, Hermit Basin and Edgar Bay, while samples for laboratory analysis were collected from the surface only at Groombridge Point.

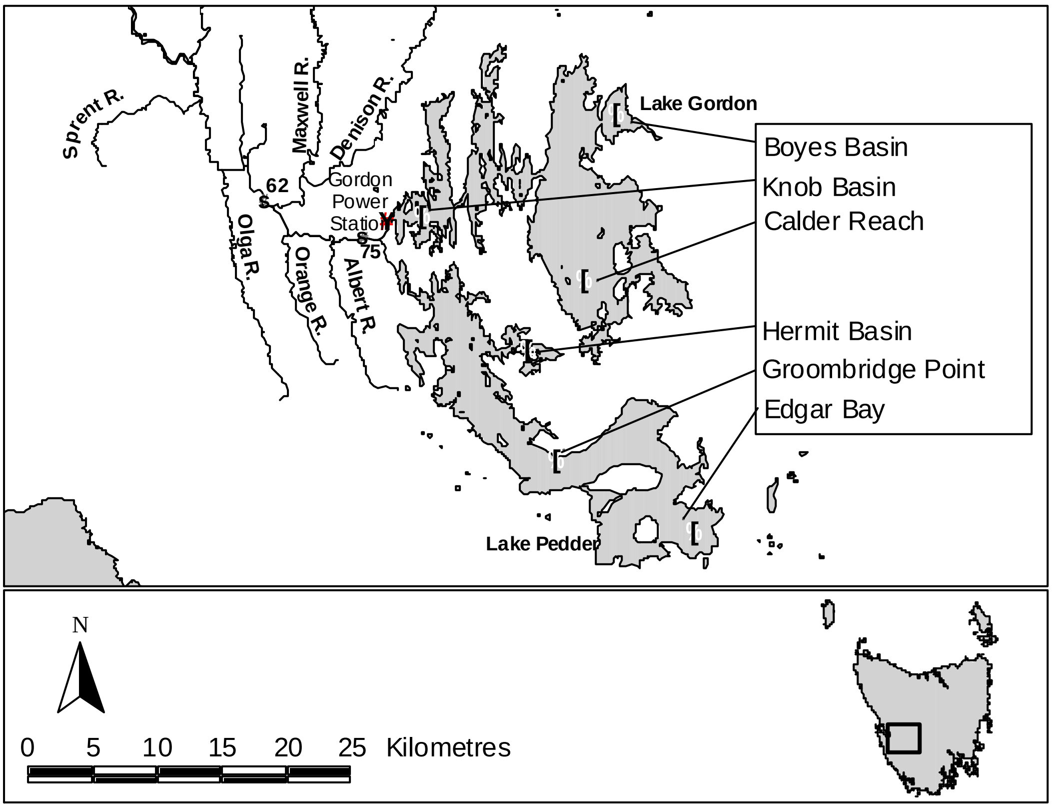


Figure 3.1. Map of the locations of water quality monitoring sites in Lakes Pedder and Gordon, and the Gordon River, for 2001-02.

3.1.3 Gordon River

Water quality monitoring was carried out remotely at three sites within the Gordon River downstream from the Gordon Power Station. These were:

- Gordon Power Station tailrace;
- Gordon River at site 75 (G4 -Albert Rapids);
- Gordon River at site 62 (downstream of the Denison junction).

Water temperature was measured at all three sites, while dissolved oxygen was also recorded at the tailrace site to monitor the changes in oxygen concentrations resulting from power station operations.

3.2 Water Quality of Lake Gordon

3.2.1 Characteristics of stratification

As a result of the complex morphology and bathymetry of the lake, stratification tends to be variable between basins. However the most pronounced stratification appears to have occurred at the same time (March 2002) at all three site. At deeper locations, pronounced stratification was also evident in June 2001. Figure 3.2 and Figure 3.3 present the profile data from the sites monitored in Lake Gordon.

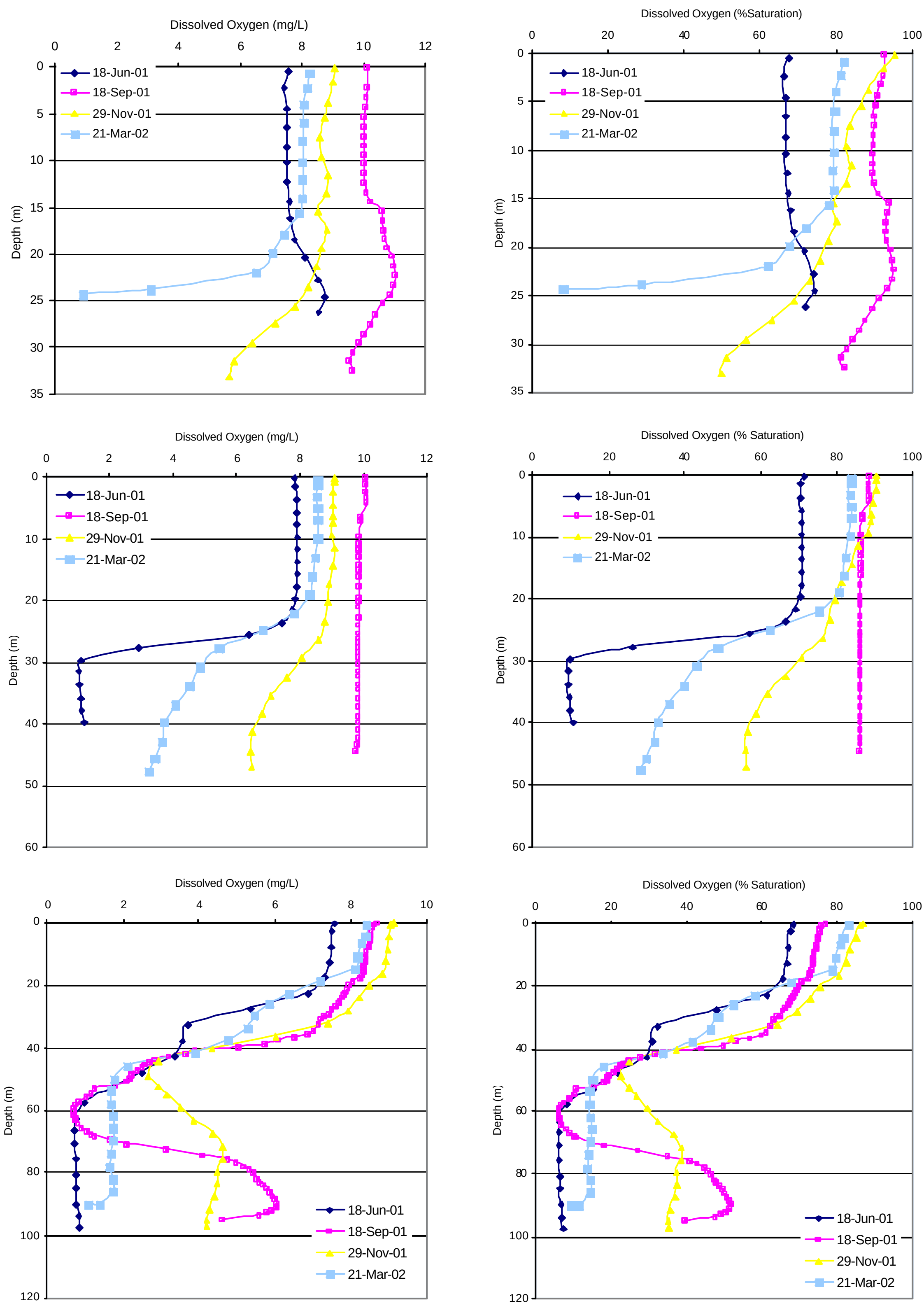


Figure 3.2. Depth profiles of dissolved oxygen at Boyes Basin (top plots), Calder Reach (middle plots) and at the power station intake (bottom plots) recorded between May 2001 and April 2002.

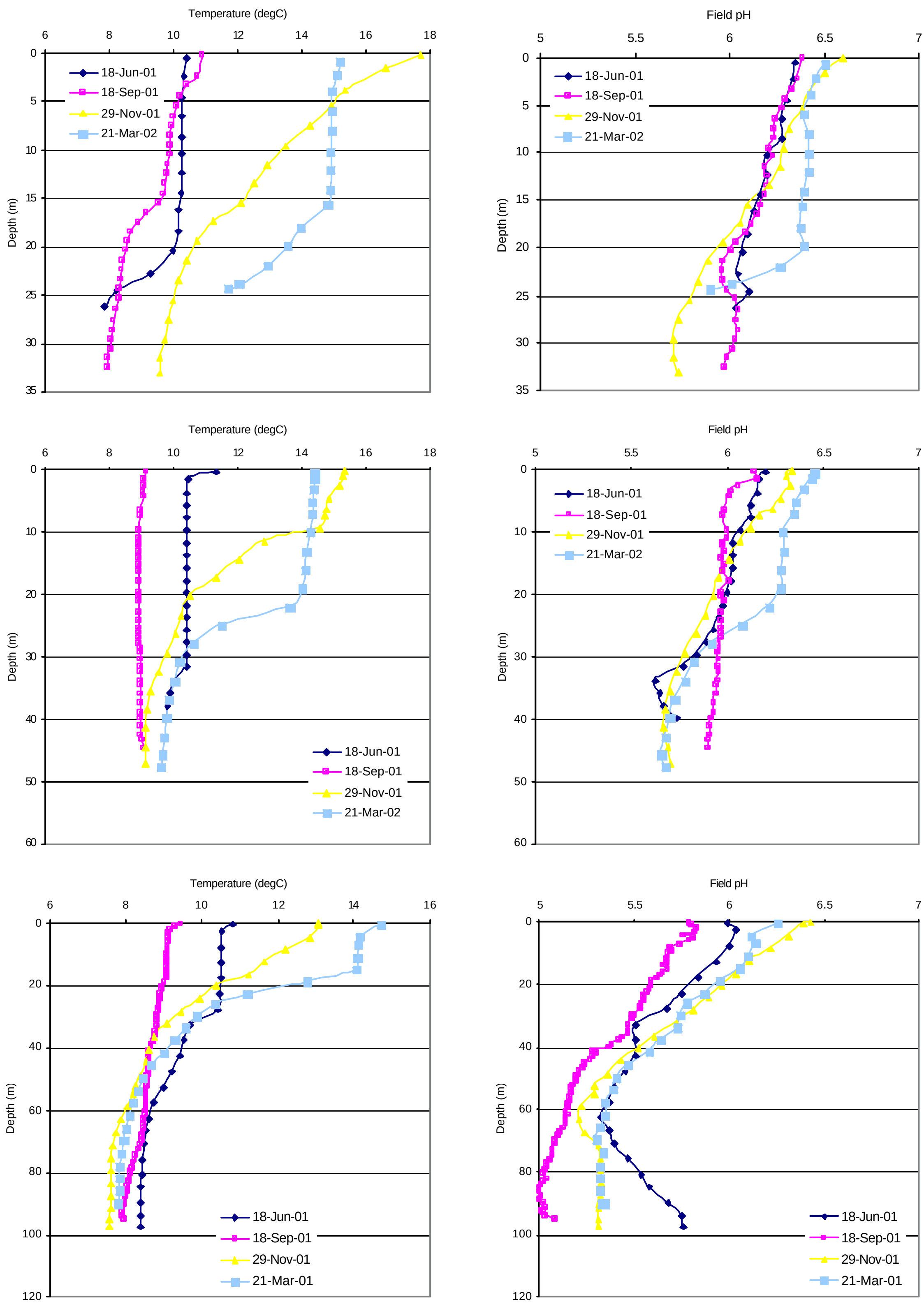


Figure 3.3. Depth profiles of temperature (left) and pH (right) at Boyes Basin (top plots), Calder Reach (middle plots) and at the power station intake (bottom plots) recorded between May 2001 and April 2002.

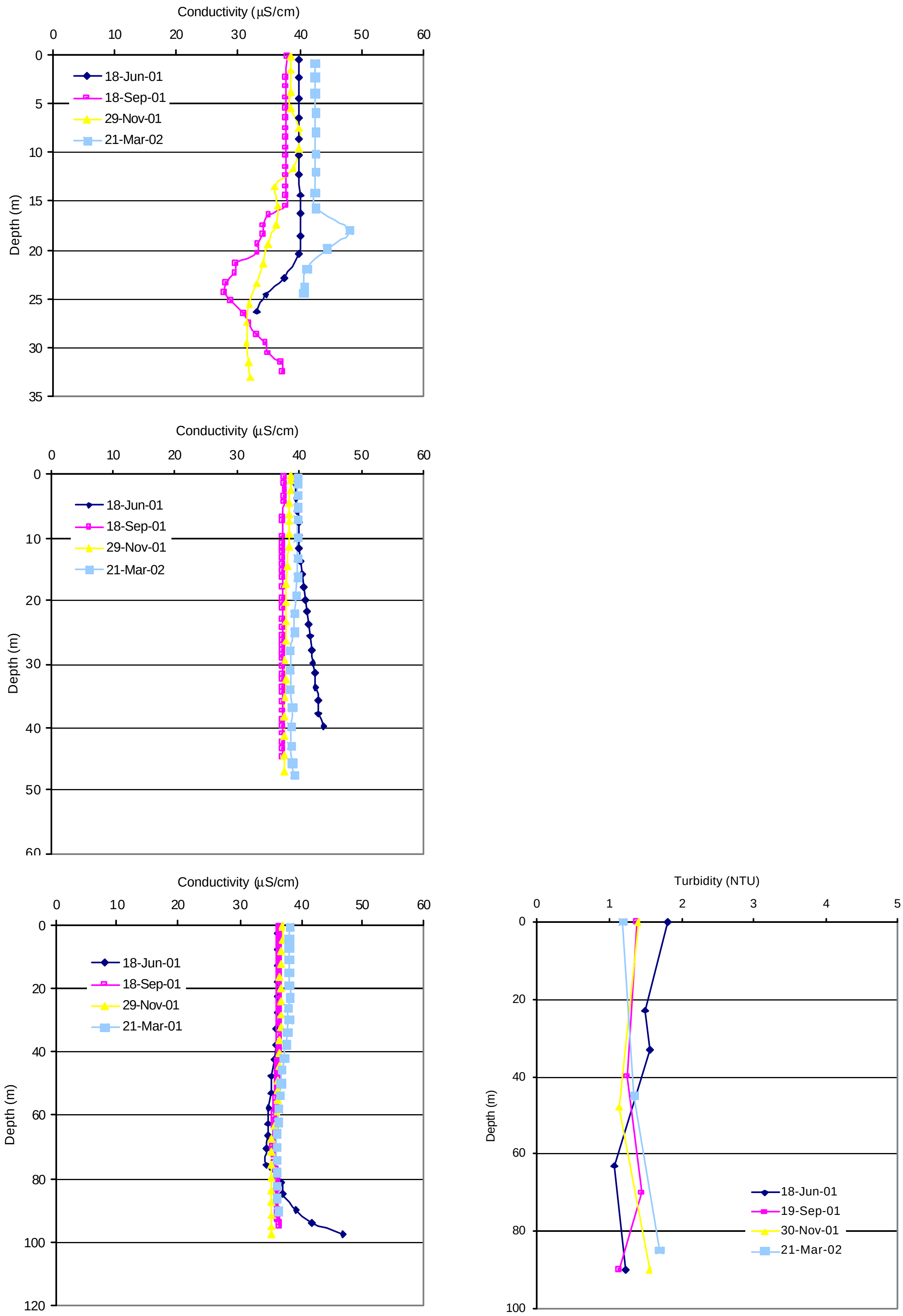


Figure 3.4. Depth profiles of conductivity (left) at Boyes Basin (top), Calder Reach (middle) and conductivity and turbidity (right) at the power station intake (bottom) recorded between May 2001 and April 2002.

The data for Boyes Basin generally reflect the influence of inflowing water from the upper Gordon River, which tends to reduce the development of stratification in this basin. Inflowing water would generally tend to be cooler than surface water in the lake during the summer months. This inflow is likely to flow into the deeper layers of the lake, preventing deoxygenation. However, dry conditions during the summer of 2002 meant that inflow volumes were lower than normal, and hence the bottom water did approach anoxia during March. Thermal stratification was most pronounced in the Boyes Basin in March 2002, although greatest thermal variation in the water column was found in November 2001: a range of almost 8^{o}C.

The pattern of thermal stratification measured at Calder Reach and the power station intake was very similar, with strongest development occurring in March 2002, when the upper 25m was warmed to about 14^{o}C. The deeper water at both sites varied by little more that 1^{o}C all year round, and virtually complete vertical thermal mixing was apparent at both sites in September 2001. This vertical mixing was also reflected in the dissolved oxygen profile at Calder Reach. Despite some penetration of oxygen enriched water into the bottom of the water column at the power station intake, a residual volume of deoxygenated water remained at mid-depth, between 50-70 m.

While all three locations showed some variation of pH with depth, the most noticeable change was found at the power station intake. Water throughout the lake tends to be mildly acidic, which is typical of water on the west coast and the southwest of Tasmania. Deep water at the power station intake site was found to have a pH as low as 5.

The profiles for conductivity in Lake Gordon (Figure 3.4) clearly show that the inflow of water into Boyes Basin alters the conductivity of water below about 15m depth. However, the profile data show that there is generally minimal vertical variation in conductivity at deeper locations.

Sampling of the water column for turbidity at the power station intake in Lake Gordon (Figure 3.4) indicated that there was no significant change in turbidity with depth in this part of the lake.

3.2.2 Surface water characteristics

The surface water quality data from Lake Gordon are summarised graphically in Figure 3.5a & b. For the purposes of this report, all surface water data from the three sites on Lake Gordon have been pooled and plotted in the form of a boxplot. In this graphical technique, the boxes represent the middle 50% of the data, with the horizontal line intersecting the box indicating the median (or 50^{th} percentile) value. The vertical bars extend out to show the 95^{th} and 5^{th} percentile values and individual dots show outliers.

The summary plots show that surface water quality in Lake Gordon is within the normal range for Tasmanian fresh waters, with healthy oxygen concentrations, low turbidity and nutrient levels and mild acidity (in this case, typical of Tasmanian west coast water). The plot for chlorophyll-*a* shows that although the majority of the data are indicative of a low productivity system, there appear to be periods when algal activity was elevated. During the November 2001 monitoring, the chlorophyll-*a* concentration exceeded 12 µg.L^{-1} at Boyes Basin, suggesting a spring bloom of algae in this area at that time. This appears to have been limited to only the Boyes Basin, as chlorophyll-*a* concentrations elsewhere at that time were only 1-2 µg.L^{-1}.

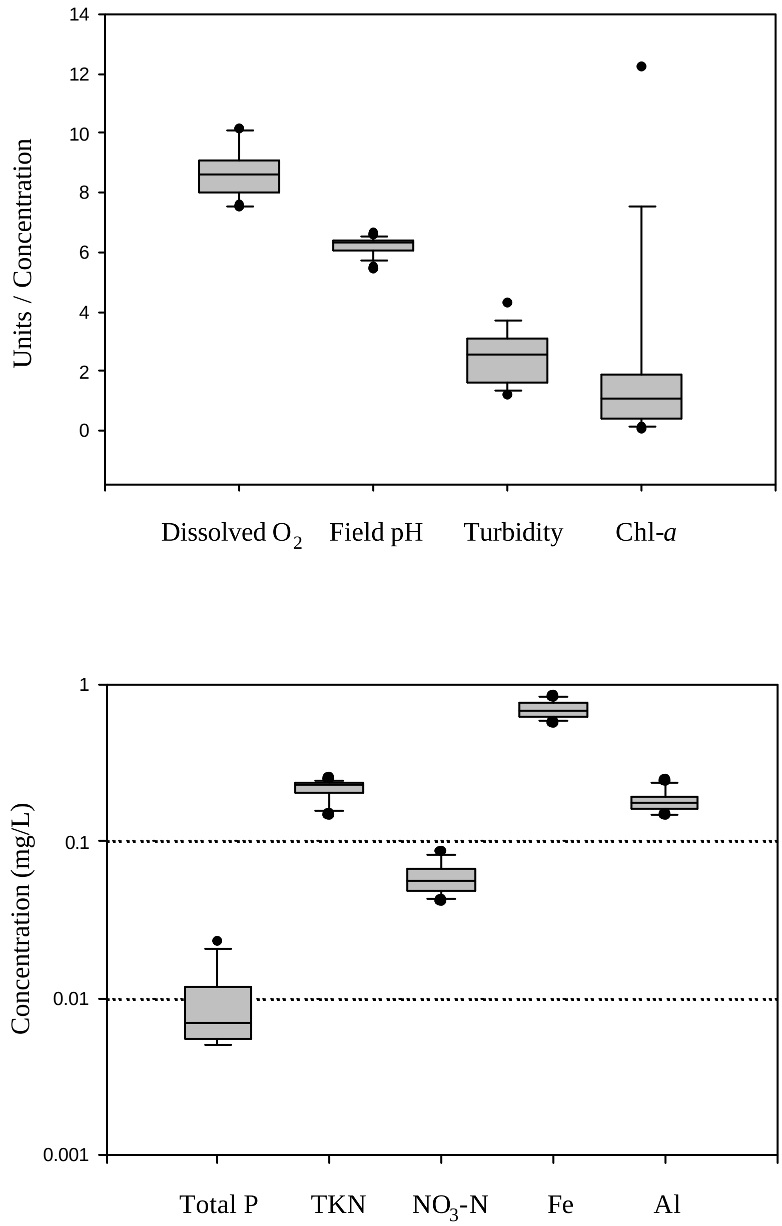


Figure 3.5a & b. Boxplots summarizing the data from surface water sampling on Lake Gordon. Units for dissolved oxygen are mg.L^{-1}; for turbidity, NTU and for chlorophyll-a, µg.L^{-1}. pH is unitless. Data from all three Lake Gordon monitoring sites have been pooled for illustrative purposes.

Iron and aluminium were the only metals detected in any significant concentrations (Figure 3.5b), although most of the common metals were measured, including Zn, Cu, Cd, Co, Cr, Ni, Mn and Pb. The concentrations of these two metals in Lake Gordon were similar to previous data collected from Lake Gordon and are consistent with concentrations found in other Tasmanian organic-rich west coast waterways (Koehnken, 2001). Although the aluminium levels exceed the ANZECC (1992) guideline concentration for the protection of aquatic ecosystems (<100 $\mu g.L^{-1}$ for freshwater with a pH<6.5), it is recognized that the presence of higher concentrations of dissolved organic matter (DOM) in Lake Gordon is likely to greatly reduce the bioavailability of aluminium and other metals (Koehnken, 1992), and is therefore unlikely to represent any threat to biological health in general.

Analysis showed that all the other heavy metals (Zn, Cu, Cd, Co, Cr, Ni, Mn and Pb) were present at or below the limit of detection (0.005 – 0.001 $mg.L^{-1}$). Mean values and concentration ranges for alkalinity, sulphate and dissolved organic carbon in Lake Gordon are show in Table 3.1 below, and are within the normal range for waters on the west coast of Tasmania.

Table 3.1. Mean values and concentration ranges for alkalinity, sulphate and dissolved organic carbon in surface waters of Lake Gordon.

	Alkalinity ($mg.L^{-1}$)	**Sulphate ($mg.L^{-1}$)**	**Dissolved Organic Carbon ($mg.L^{-1}$)**
Lake Gordon	8.02 (6-10)	0.95 (0.92-1.0)	5.78 (2.2-9.9)

3.3 Water Quality of Lake Pedder

3.3.1 Characteristics of stratification

The profile data from Lake Pedder were collected from Groombridge Point. These data, shown in Figure 3.6, clearly illustrate that Lake Pedder does not stratify to any notable degree and is well mixed for most of the year.

There were no other significant features of the profile data from Lake Pedder. These data show a water body with water quality characteristics similar to other west coast lakes.

3.3.2 Surface water characteristics

The surface water quality data collected from sites in Lake Pedder are summarised graphically in Figure 3.7a & b. The data indicate that water quality in Lake Pedder was good, with healthy oxygen concentrations and low turbidity. Similar to Lake Gordon, pH in Lake Pedder is typical of lakes on the west coast of Tasmania, and algal activity, as indicated by chlorophyll-*a* values, was low.

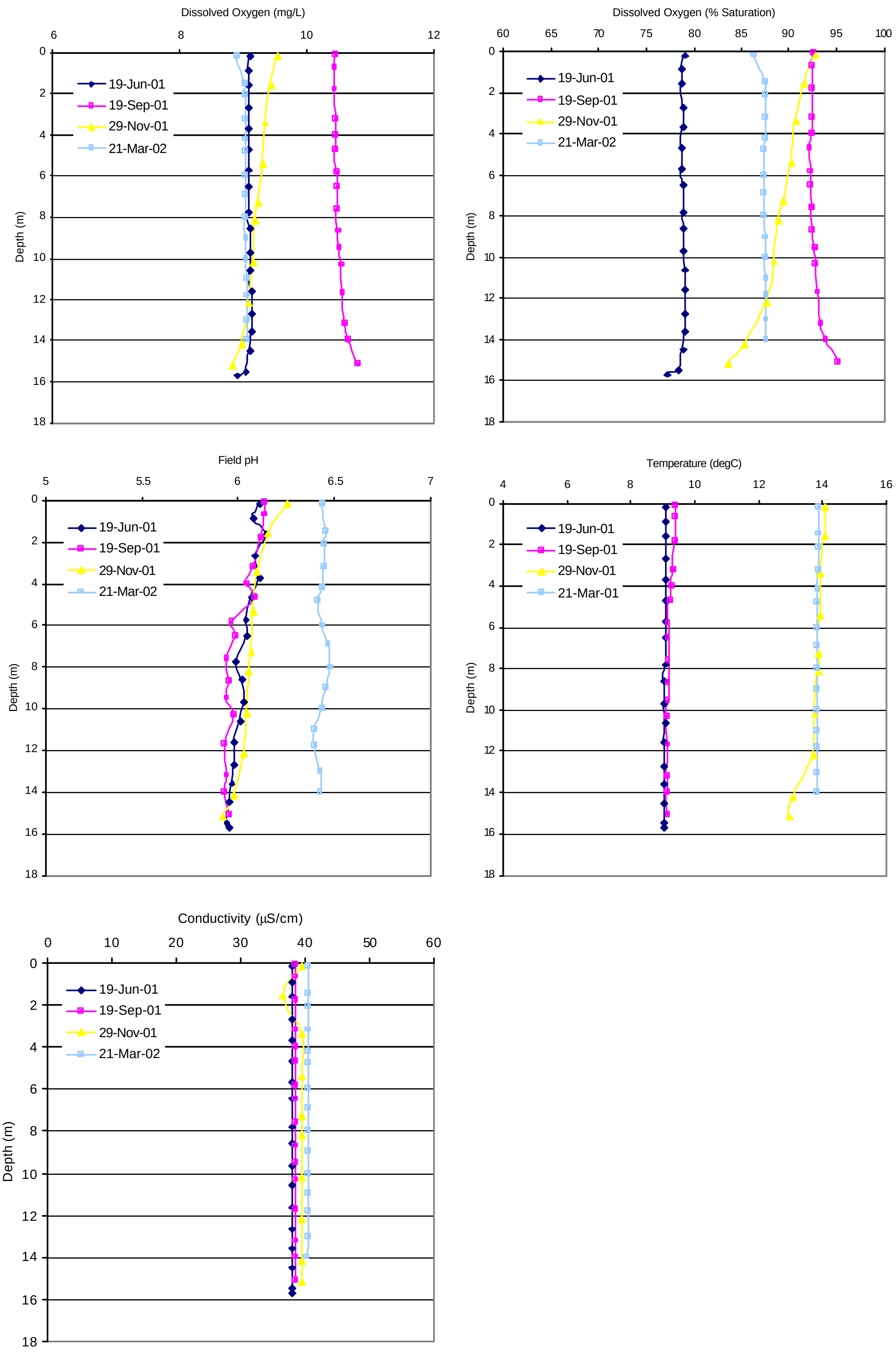


Figure 3.6. Depth profile characteristics in Lake Pedder off Groombridge Point recorded between May 2001 and April 2002.

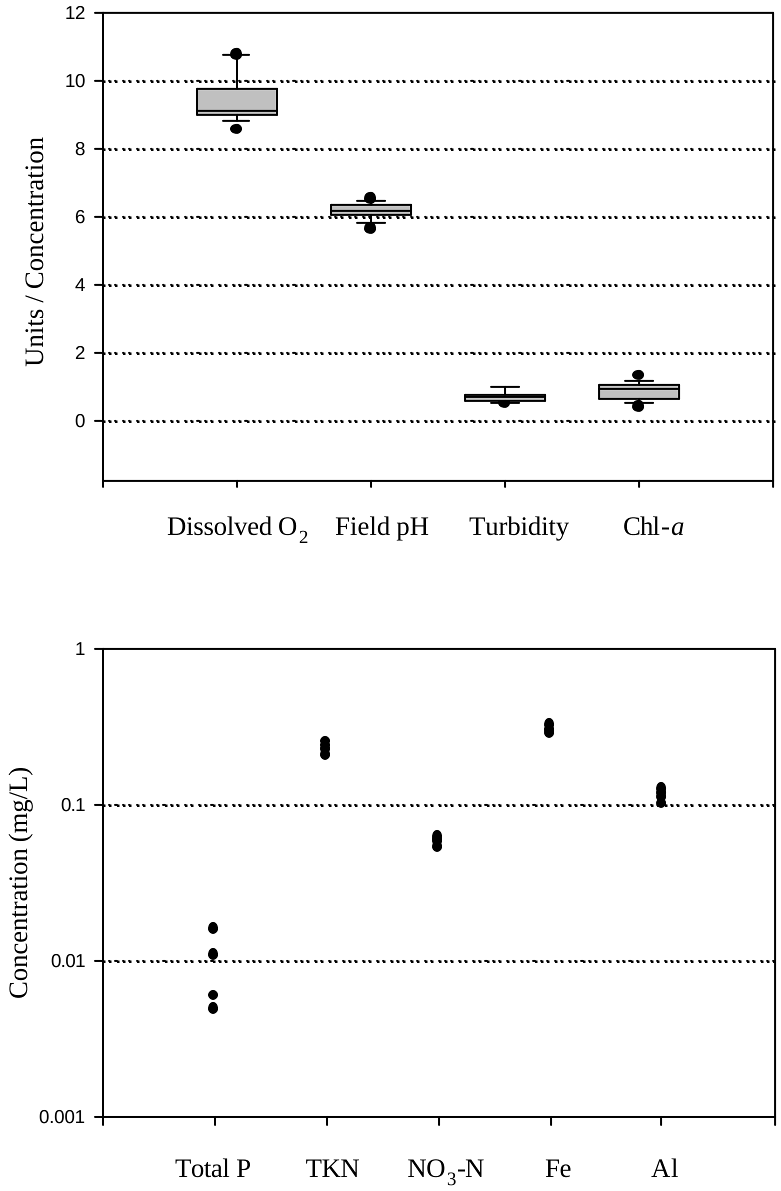


Figure 3.7a & b. Boxplots and vertical scatter plots showing the data from surface water sampling in Lake Pedder for 2001-02. Units for dissolved oxygen are $mg.L^{-1}$; for turbidity, NTU and for chlorophyll-a, $\mu g.L^{-1}$. pH is unitless. Data from all Lake Pedder sites have been pooled in figure 3.8a for illustrative purposes.

The nutrient and metal concentrations measured in Lake Pedder are almost identical to those found in Lake Gordon during this round of monitoring. The nutrient values are well below the default trigger levels for the protection of ecosystems in slightly disturbed environments in Tasmania as recommended in the recently revised edition of the National Water Quality Guidelines (ANZECC, 2001), while the metal concentrations are of no environmental concern given the level of dissolved organic matter in the water of this lake (see previous comments regarding metals in Lake Gordon, Section 3.2.2).

Analysis showed that all the other heavy metals (Zn, Cu, Cd, Co, Cr, Ni, Mn and Pb) were present at or below the limit of detection (0.005 – 0.001 $mg.L^{-1}$). Mean values and concentration ranges for alkalinity, sulphate and dissolved organic carbon in Lake Pedder are show in Table 3.2 below, and are not markedly different from those recorded in Lake Gordon.

Table 3.2. Mean values and concentration ranges for alkalinity, sulphate and dissolved organic carbon in surface waters of Lake Pedder.

	Alkalinity ($mg.L^{-1}$)	**Sulphate ($mg.L^{-1}$)**	**Dissolved Organic Carbon ($mg.L^{-1}$)**
Lake Pedder	5.65 (5-7)	1.02 (0.97-1.1)	6.33 (2.1-12)

3.4 Water Quality in the Gordon River

Because of the lead-time required for the production of this report, the water quality data reported here cover the period 1st May 2001 to 30th April 2002. Water temperature was monitored at three remote sites within the Gordon River, including:

- Gordon Power Station tailrace;
- Gordon River at site 75;
- Gordon River at site 62.

Dissolved oxygen was monitored only at the power station tailrace.

3.4.1 Water Temperature

Water temperature in the Gordon River immediately downstream from the Gordon Power Station is primarily controlled by conditions in Lake Gordon at the level of the intake. Figure 3.8 shows the high degree of correlation between water temperature at the tailrace site and site 62 (downstream of the junction with the Denison River) some 15 km downstream. The main difference between the water temperatures recorded at these two sites is the increased level of daily variation evident at the downstream site, although the water temperature was also generally slightly higher. This is more clearly shown in Figure 3.9, where the data from Nov-Dec 2001 are plotted.

During brief shut-downs of the power station in June and July of 2001, both sites showed the level of daily variation that might be experienced during winter under 'unregulated' flow conditions.

3.4.2 Dissolved Oxygen

The potential influence of oxygen stratification at the power station intake on water used for power generation is shown in Figure 3.10. This figure illustrates the change in oxygen concentration of water at the level of the intake in Lake Gordon, using depth profile data collected over the past couple of years. It shows that, despite a decline in lake level over the period, the oxygen content of water being drawn into the power station appears to have consistently been within the range of 6 - 8 $mg.L^{-1}$.

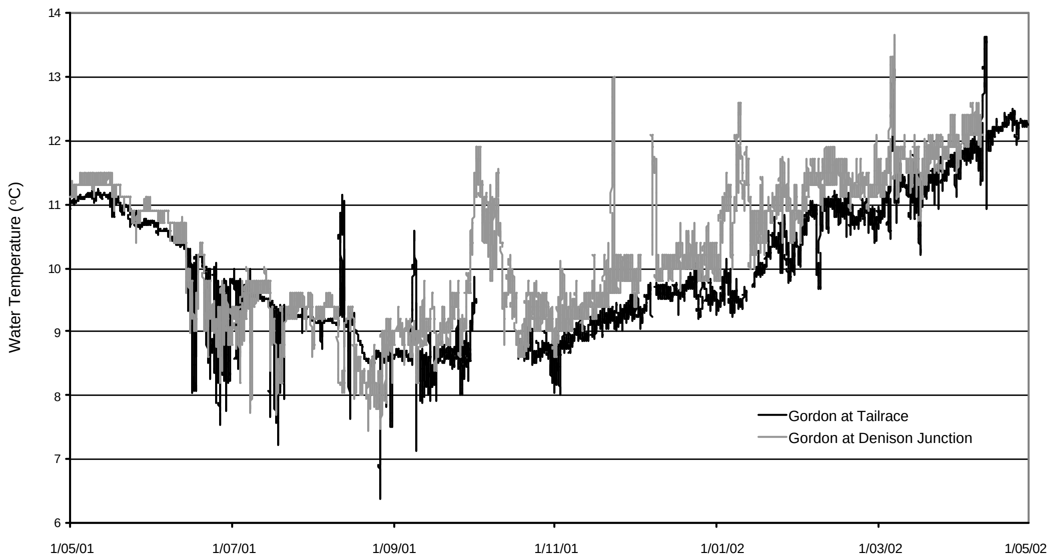


Figure 3.8. Water temperature variation in the Gordon River at the power station tailrace and at the junction of the Gordon and Denison rivers (site 62, approximately 15km downstream).

Note: The data from Albert Rapids (site 75) has not been included as it shows no difference from that recorded at the tailrace site.

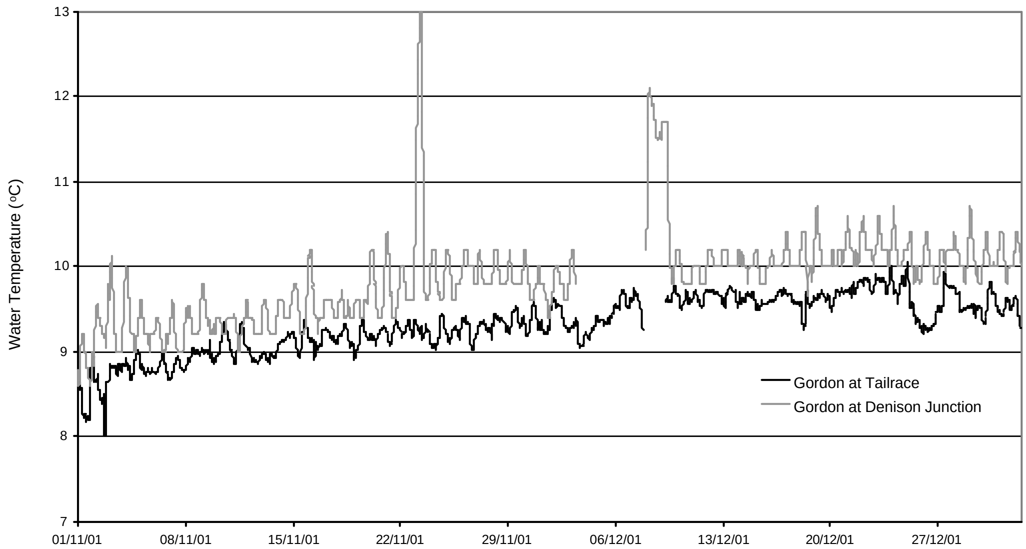


Figure 3.9. Water temperature data for Nov-Dec 2001, showing more clearly the 0.5-1.0° C difference between water temperature at the power station tailrace (dark line) and the Gordon River at the Denison River junction (site 62). It also illustrates the greater range of daily temperature variation at the latter site.

These data imply that the water being discharged from the power station during the recent period of monitoring is not likely to have contained sufficiently low oxygen concentrations to pose a significant risk to instream biota in the Gordon River downstream. This is confirmed to some degree by the data collected from the tailrace (discussed in section 3.4.2). Oxygen concentrations recorded in the tailrace appear to have been about 0.5 $mg.L^{-1}$ lower.

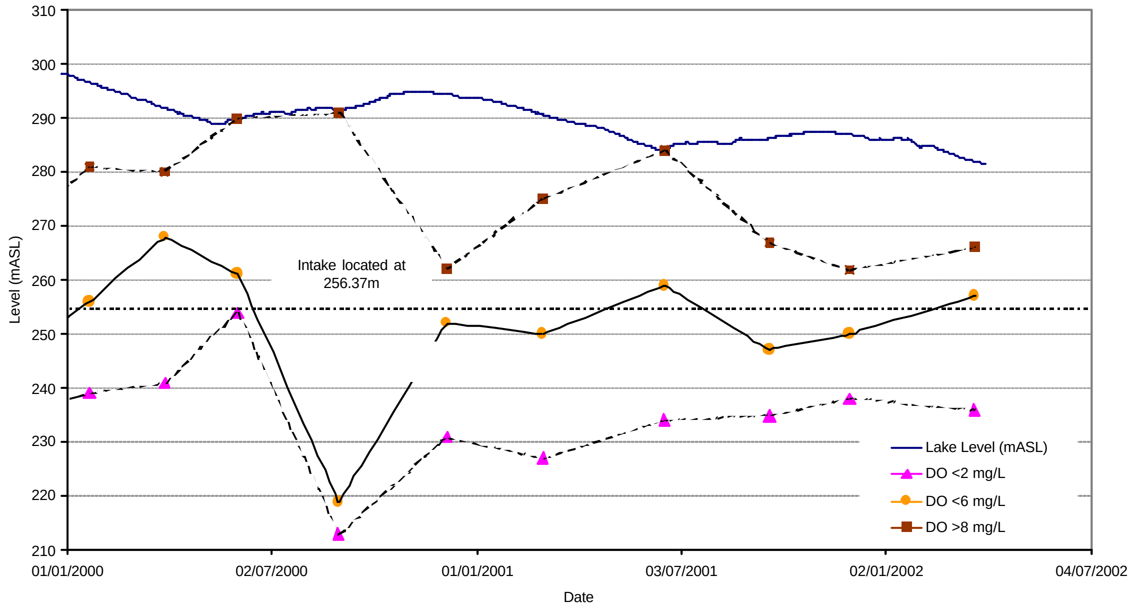


Figure 3.10. Changes in dissolved oxygen profile characteristics in Lake Gordon at the power station intake, along with changes in lake level since January 2000.

The trace for dissolved oxygen (DO) concentration at the power station tailrace is shown in Figure 3.11. There is a 2-month gap in the data due to failure of the dissolved oxygen sensor and a shorter gap during October when data could not be retrieved.

Figure 3.11 includes notes that show the dissolved oxygen concentrations measured in Lake Gordon at the approximate level of the intake. These provide useful cross-references for the tailrace data, and indicate that the tailrace data can be used to demonstrate changes in the characteristics of lake water at the power station intake. This is indicated by the baseline (minimum levels) of the trace.

The tailrace DO data are characteristic of conditions below hydro-electric power stations. Sharp spikes in the trace generally indicate the occurrence of air injection during some stages of turbine operation. The highest of these spikes tend to occur during start-up following periods of shut-down (eg. 13th August 2001 and 14th January 2002), when multiple machines are being initiated. However the majority of spikes are much smaller and are a reflection of minor changes to operations of individual turbines.

The spikes in DO resulting from turbine operations can lift concentrations by as much as 5 mg.L^{-1}. Where the intake water already contains high concentrations of DO (eg late December 2001), this may increase the risk of supersaturation. However, this risk appears to have been low for most of the study period. During 2001-02 the DO concentration in the intake water showed some evidence of a seasonally changing pattern, from a mid-winter low of around 5 mg.L^{-1} to a summer high of around 8 mg.L^{-1}.

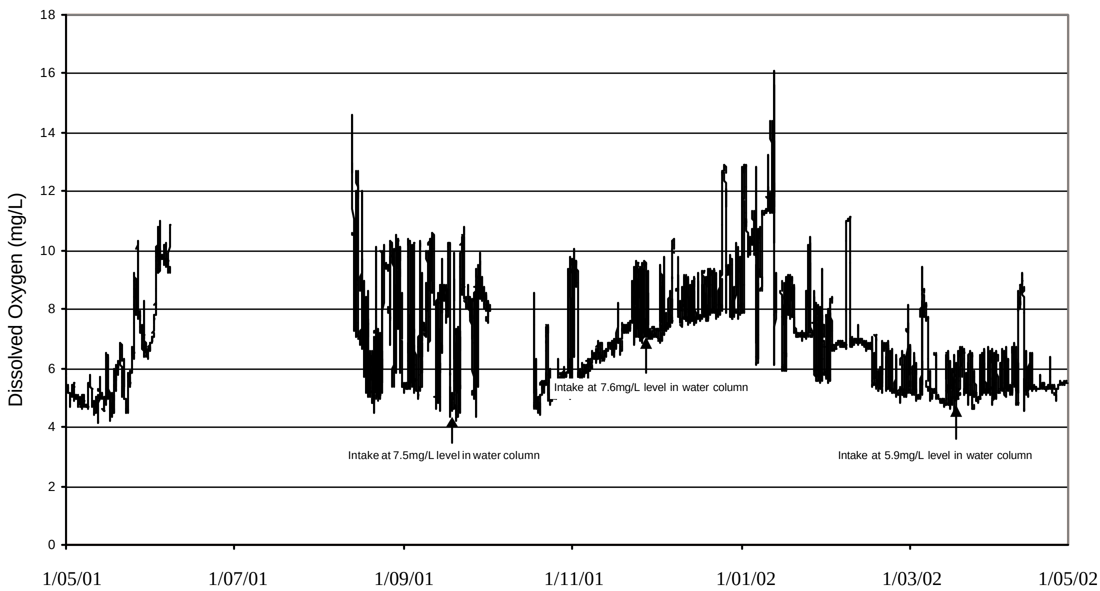


Figure 3.11. Dissolved oxygen concentration in the Gordon River at the power station tailrace. Arrows on the plot also show the measured concentration of oxygen in the water column at the level of the intake during periods when profile data were recorded in Lake Gordon.

3.5 Gas supersaturation

The main water quality issue identified for the Gordon River downstream of the Gordon Power Station by Koehnken (2001) was that of 'spiking behaviour' in dissolved oxygen concentrations in water being discharged from the power station. Air injection is used during power generation to increase the mechanical efficiency of individual turbines when they are under intermediate loads. During air injection, dissolved oxygen concentration in the discharge water can increase by as much as 5 mg.L^{-1}. When the water already contains appreciable concentrations of oxygen (and other gases) prior to power generation, this can produce 'supersaturation' of dissolved gas, and this may present a threat to aquatic biota in the river downstream.

While the measurement of dissolved oxygen alone does not identify the level of total gas saturation in water, it can be used to indicate the approximate level of total gas saturation (Bobbi, 2000). The oxygen concentration data from below Gordon Power Station can be converted to percent saturation using an algorithm that uses dissolved oxygen concentration, electrical conductivity and water temperature (APHA, 1992). From this and other reference sources, it is estimated that total gas supersaturation starts to develop when oxygen saturation exceeds about 105%. In concentration terms, this equates to roughly 12-13 mg.L^{-1} of dissolved oxygen at a water temperature of about 10^{o} C in water exhibiting the low conductivity of Lake Gordon. The ANZECC (2001) guideline for total dissolved gas saturation in freshwaters has been set at 105% for the protection of aquatic biota.

At the Gordon Power Station, air injection takes place when power output from each turbine is less than about 110MW. Therefore when any of the three turbines is operating below that output level, there is potential for the generation of gas supersaturation in at least part of the discharge water. It is therefore important to examine the pattern of use of all three turbines when trying to interpret changes in dissolved oxygen in the discharge water.

Further study of supersaturation in the Gordon River downstream of Gordon Power Station is planned prior to the commencement of Basslink. This study will;

- examine the degree to which water discharged from Gordon Power Station is saturated in terms of total gas as well as dissolved oxygen; and
- examine the distance that supersaturated water is carried downstream, and whether the physical characteristics of the river act to exacerbate or ameliorate levels of dissolved gas.

The field study will be carried out when the power station is operating in the intermediate load range and when the intake to the power station is drawing in water from above the oxycline (>8 $mg.L^{-1}$). It is these two factors have been shown from the data to result in higher gas saturation. These conditions generally apply in the winter months.

3.6 Conclusion

Surface water quality in both Lakes Gordon and Pedder is characteristic of lakes in the west and southwest of Tasmania, with low nutrient concentrations and turbidity, mildly acid pH and generally low algal activity. While the majority of heavy metal analytes were not detected in any significant concentration, higher levels of iron and aluminium are not considered to be of environmental concern due to the abundance of dissolved organic matter in these waters. Iron concentration in Lake Gordon is in the range that may impact on aesthetics (taste) for human consumers (ANZECC 1992).

Stratification (thermocline and oxycline) appears to be relatively stable in deeper waters in Lake Gordon (at the power station intake). However the precise influence this has on the quality of water being drawn into the power station may be variable, as the depth of the intake appears to generally fall within the thermocline. Small changes in the characteristics of stratification may therefore have larger impacts on the quality of intake water.

The data from water temperature monitoring in the Gordon River supports earlier conclusions (Koehnken, 2001) regarding the influence of Lake Gordon on water temperature in the lower Gordon River. These data show that although there is still a broad seasonal signal, this is likely to be less than would be expected in an unregulated system. In a similar manner, diurnal variation appears to be depressed in the lower Gordon River as a result of flow regulation.

The data for dissolved oxygen concentration in the discharge water indicate that supersaturation of the discharge water may be an issue when the intake water already contains appreciable amounts of dissolved gas. This does not appear to have been a significant issue during the past year.

4 Fluvial Geomorphology

4.1 The fluvial geomorphology monitoring program

The fundamental objective of the fluvial geomorphology monitoring program is to document fluvial geomorphic changes on the banks of the middle Gordon River between the power station tailrace and the mouth of the Franklin River, and to relate these changes to power station operations or other factors wherever possible.

Scour and seepage erosion are the major focus of the monitoring program, as these processes have been identified as the dominant erosion processes presently affecting alluvial banks and the ones most likely to be affected by Basslink.

The fluvial geomorphology monitoring program focuses on the same study area as the initial Basslink investigations (Koehnken *et al.* 2001). Little previous geomorphic work had been completed in the study area, so the Basslink investigation findings were based on field observations and analysis of one year of results from hydrologic records, erosion pins, scour chains and in-bank peizometers. The initial Basslink investigations identified five geomorphic zones in the study area which are shown in Figure 4.1. These zones were used in the implementation, presentation and discussion of the monitoring program.

A major field component of the Basslink geomorphology investigations (Koehnken *et al.* 2001) was the mapping of bank characteristics on both sides of the river over the length of the study area. The mapping identified the following bank characteristics on a reach by reach basis:

- underlying material (sandy alluvium or colluvium, cobbles, bedrock);
- height to green vegetation (indication of water level fluctuations);
- percent cover on bank of large woody debris (LWD);
- percent tea-tree on banks;
- slope of bank, extent and nature of buttressing of bank toe, and level of recent activity (recent tree falls, active seepage erosion).

These characteristics were found to be important to overall bank stability in the middle Gordon River, and monitoring sites that reflect a range of these characteristics, as well as position in the river (inside bend, outside bend, above/below constrictions, etc), have been incorporated into the monitoring program.

Erosion pin and scour chain sites that were established as part of the original Basslink investigations have been retained, providing a record of erosive activity since December 1999.

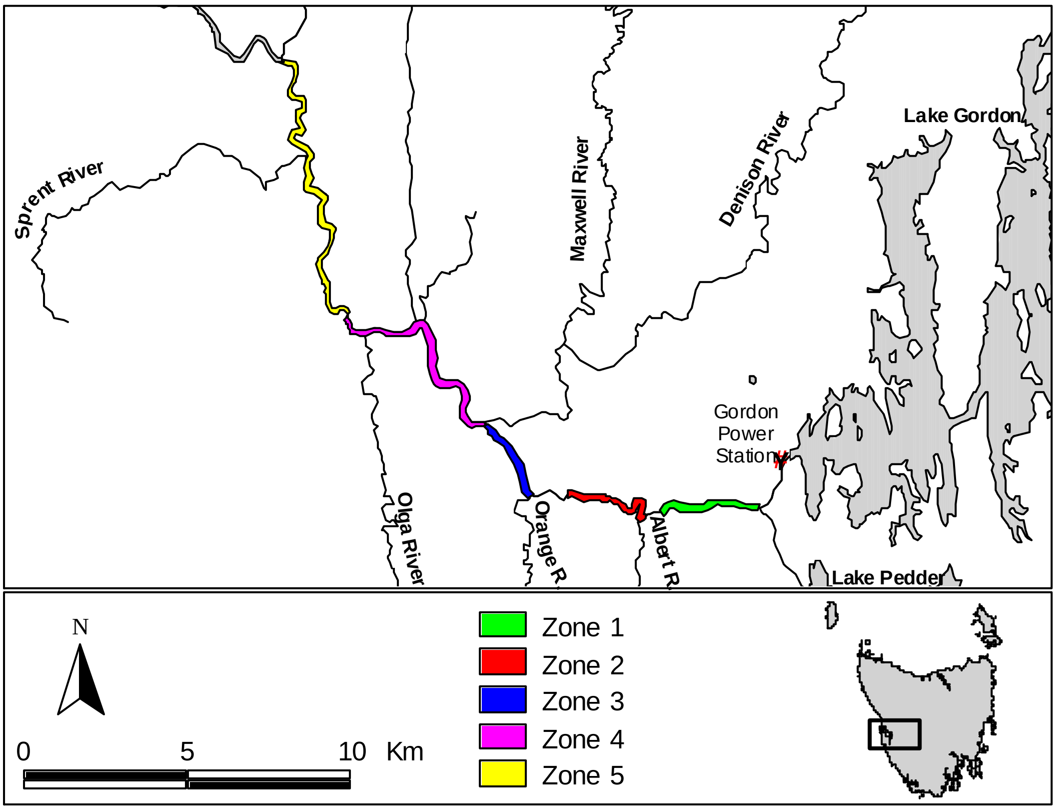


Figure 4.1. Geomorphology zones in the middle Gordon River.

4.2 Methodology

4.2.1 Monitoring approaches

A number of approaches have been adopted for the geomorphology monitoring program. These include:

- The installation of erosion pins and scour chains in sandy alluvial and colluvial banks;
- The installation of erosion pins in vertical cobble banks;
- Photo-monitoring of selected banks and features (landslips, tree falls, cobble bars); and,
- The expansion and upgrading of the peizometer array in Zone 2.

The approach and rationale adopted for each of these monitoring techniques is discussed in the following sections.

4.2.1.1 Erosion pins and scour chains

A total of 48 erosion pin sites (>200 pins) and 25 scour chain sites have been established in the middle Gordon River. The erosion pins consist of 10 mm diameter steel rods varying in length between 500 mm and 3,000 mm, with the majority between 1,000 mm and 1,500 mm. Scour chains are approximately 1.5 m long and composed of links each ~25 mm in length.

Considerable judgement is required in the selection of erosion pin sites. As much as possible, the sites have been selected such that the ranges of bank characteristics (active seepage erosion; steeply / shallowly sloping; abundance of LWD; inside / outside bend; vegetation communities, buttressing, etc) documented during the bank mapping exercise are reflected in the monitoring sites in each zone.

On banks affected by seepage erosion, primarily upstream of the Denison River, erosion pins were typically installed in a horizontal position within the cavities on the vertical wall of the bank, and in a vertical position in the sediment flows on the lower banks and at the toe of the bank. On sandy alluvial banks not experiencing seepage erosion, pins were typically placed in a vertical position. These were aligned in a transect perpendicular to the flow of the river, with the transect extending from the toe of the bank, up the bank slope and into the overlying colluvium, or were placed parallel to the river along the bank toe. At selected sites, pins were also installed in, or adjacent to, some bank features, such as gullies and tree falls.

The field measurement of erosion pins also involves judgment, as the contact surface where the pin meets the bank surface is rarely uniform and can change with time. During the initial Basslink investigations, measurements were made by a variety of people along the shortest side of the pin. In an attempt to reduce the variability of measurements, the 2001-02 monitoring program measured two points on the pins, the upslope and downslope sides for vertically placed pins, or in the case of pins inserted horizontally into bank faces, the top and bottom. In this report, the 'top' measurements are presented for pins on vertically inserted on bank slopes, and the 'bottom' measurements are used for pins horizontally inserted in bank faces. These are easier to measure and likely to be more accurate.

Erosion pins installed in deep (>1 m) bank cavities were difficult to measure, as the exposed pin length may be up to 2m long, and measurements involve carefully moving the tape measure along the bottom of the pin, weaving through a web of exposed roots. It is likely that some of these measurements may have several centimetres of error. A new system of measurement which will reduce error is being considered for future monitoring.

At two sites, one in Zone 2 (Site 2F) and one in Zone 4 (4C), erosion pins were driven horizontally into vertical cobble banks between low water level and full-gate operating level. The nature of the cobble bank materials made the installation of these pins difficult, with material dislodged near the pin during installation. This local disturbance has been enlarged by scour at the base of the pin during the three month monitoring period and raises questions about the suitability of erosion pins to document processes affecting vertical cobble banks. Photo-monitoring of cobbles will assist with the long-term interpretation of the erosion pin results.

Three to seven scour chains were installed in each zone, typically mid-slope on sandy alluvial banks. Several chains were purposely placed downslope of cavities on banks prone to seepage erosion.

Monitoring of the scour chains involved measuring and describing any deposition that has occurred on the chain, and measuring and counting the links of the chain that were lying horizontal on the bank slope. The chains were 'reset' by removing deposited material and laying the exposed chain on the surface of the banks stretching in the downstream direction.

4.2.1.2 Photo-monitoring

Photo-monitoring sites were established in all zones, and focused on geomorphic processes not easily documented using erosion pins or scour chains, such as the evolution of tree falls and land slips. Photo-monitoring sites also included cobble bars and cobble banks, and sandy alluvial banks. A total of 54 sites were established for the geomorphology monitoring. Additional photo-monitoring sites in each zone have been established by the riparian vegetation monitoring program. These will used to better understand the link between vegetation and geomorphic processes in the middle Gordon River.

Photos of each erosion pin site were taken following installation of the site. These photos will be used during the analysis of erosion pin data, and will be repeated as changes at the sites are documented.

4.2.1.3 Expansion and upgrading of Zone 2 peizometers sites

In Zone 2, at site 71, a line of peizometers was established in early 2000 (Koehnken *et al.,* 2001), consisting of 5 probes extending from power station 'off' low-water level to approximately 23 m inland. The reasons for installing the site were:

- to examine rates of water level decrease with the turning off of the power station:
- to examine how this links with occurrences of seepage flows out of the banks; and
- to establish rates of bank saturation under various power station operating patterns.

For these reasons, the site was located in what has been identified as one of the most active regions of the river with respect to seepage flows. The site is subjected to large (~4 m) water level fluctuations and high rates of change, while still being a physically stable site itself.

It was originally intended to use the probes for the duration of the initial Basslink investigations only. Because of the importance of understanding bank saturation and how it relates to seepage erosion processes, Hydro Tasmania upgraded the installation using more robust probes and installed solar panels as a more reliable power supply. The installation will be maintained for the duration of the Basslink monitoring program.

Each probe records water level at 15-minute intervals with the output stored in a data logger. A newly established helipad allows access to the peizometer site, guaranteeing accessibility to the data even during periods when power station shutdowns are not possible.

4.2.2 Timing and frequency of monitoring

Monitoring is scheduled for March and October, with shutdowns and river access provided for 2-days. During this period, all erosion pin and scour chain sites must be measured and photo-monitoring sites recorded. Any alterations to the monitoring infrastructure (installation of additional pins, establishment of new sites) must also be completed during this time.

4.2.3 Geomorphology monitoring sites

A total of 46 sites were monitored during 2001-02 over the five zones of the middle Gordon River (see Figure 4.1). The location and arrangement of monitoring sites and photo-monitoring sites are illustrated in the following figures:

- Figure 4.2 shows the locations of the six geomorphic monitoring sites and five photo monitoring sites established in Zone 1 of the Gordon River;
- Figure 4.3 shows the locations of the 12 geomorphic monitoring sites and 11 photo monitoring sites established in Zone 2;
- Figure 4.4 shows the locations of the seven geomorphic monitoring sites and five photo monitoring sites established in Zone 3;
- Figure 4.5 shows the locations of the eight geomorphic monitoring sites and eight photo monitoring sites established in Zone 4; and
- Figure 4.6 and Figure 4.7 show the locations of the 13 geomorphic monitoring sites and 21 photo monitoring sites established in Zone 5.

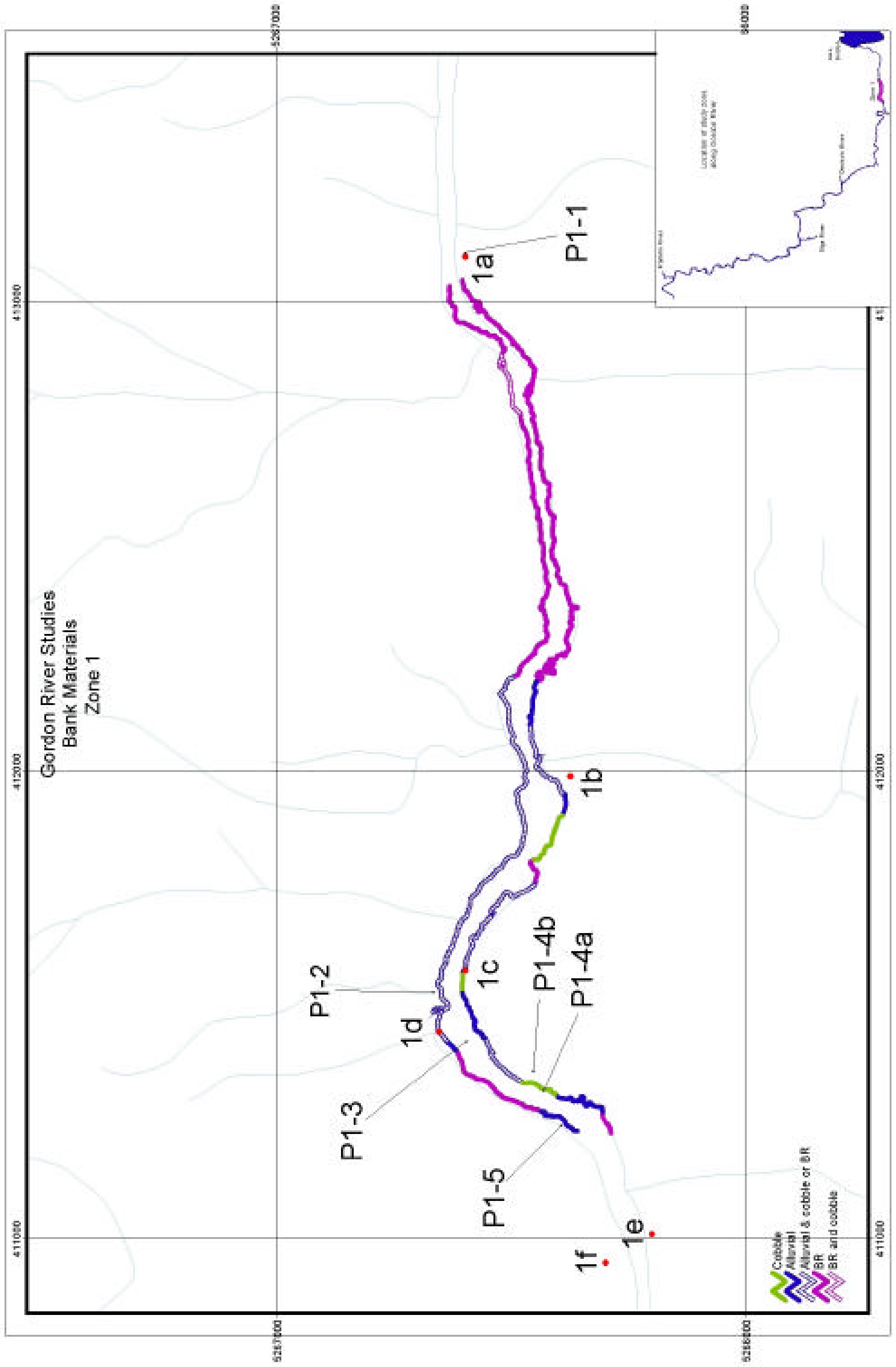


Figure 4.2. Map of the geomorphic monitoring sites (1a – 1f) and photo-monitoring sites (P1-1 to P1-5) in Zone 1 of the Gordon River, 2001-02.

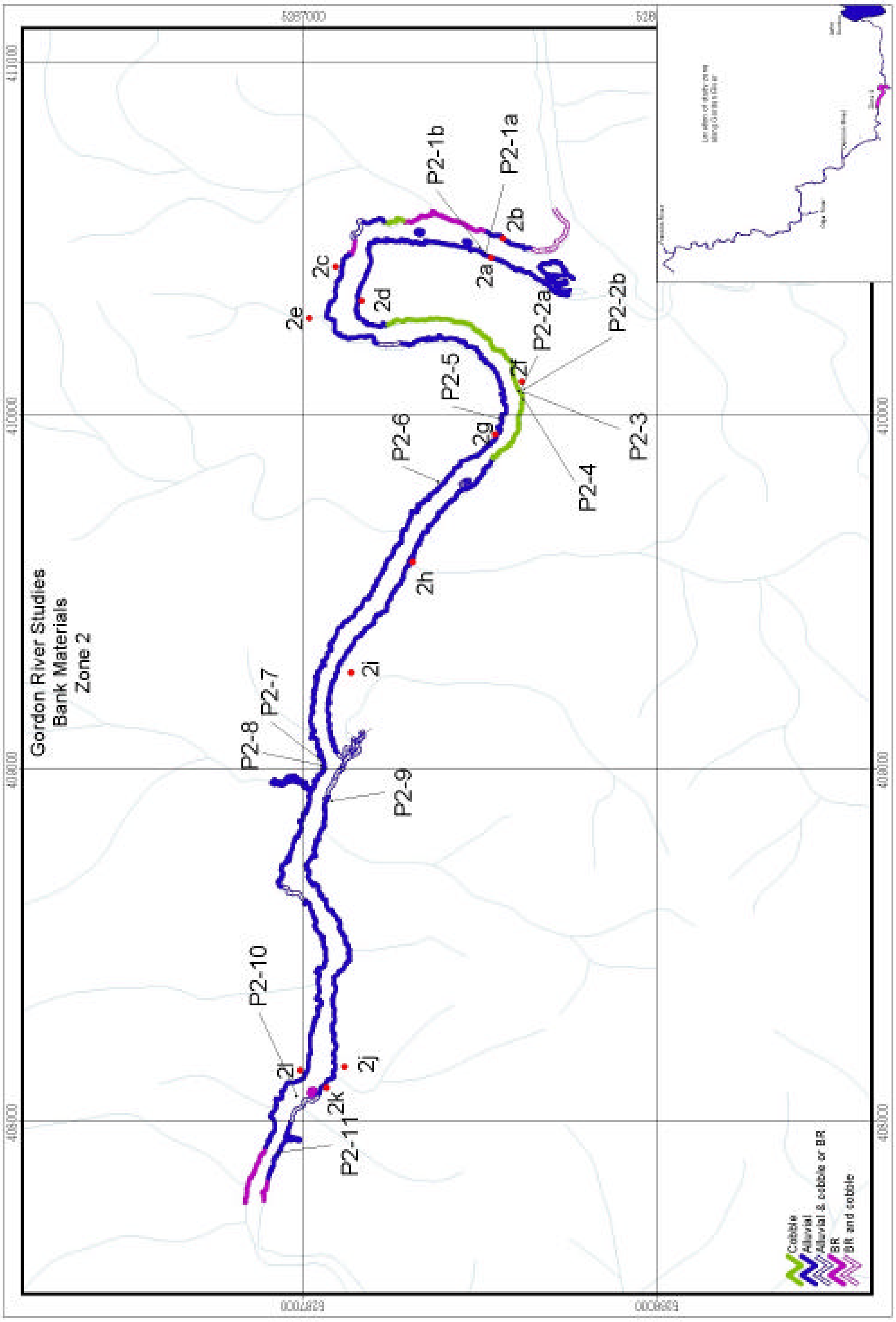


Figure 4.3. Map of the geomorphic monitoring sites (2a – 2L) and photo-monitoring sites (P2-1 to P2-11) in Zone 2 of the Gordon River, 2001-02.

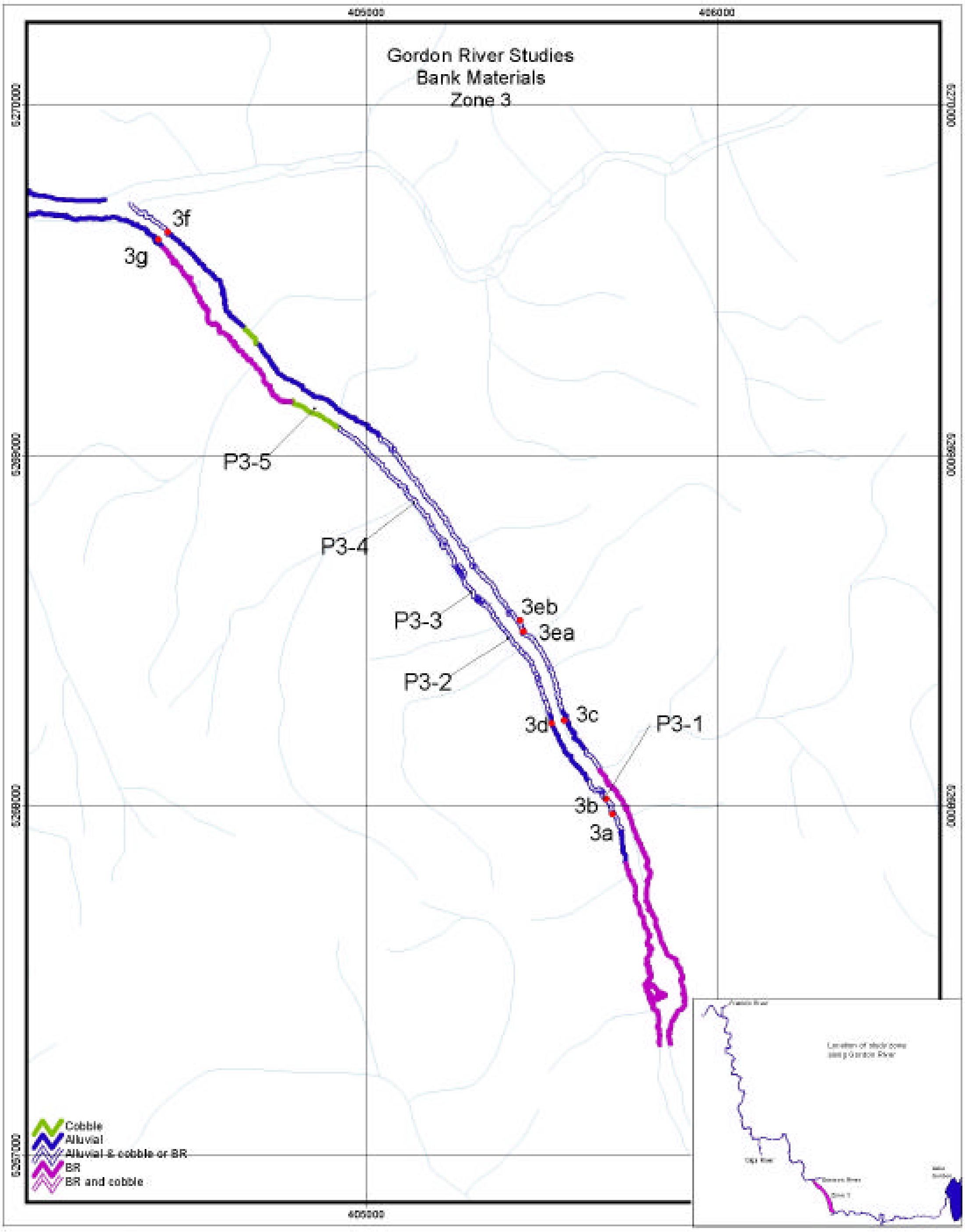


Figure 4.4. Map of the geomorphic monitoring sites (3a – 3g) and photo-monitoring sites (P3-1 to P3-5) in Zone 3 of the Gordon River, 2001-02.

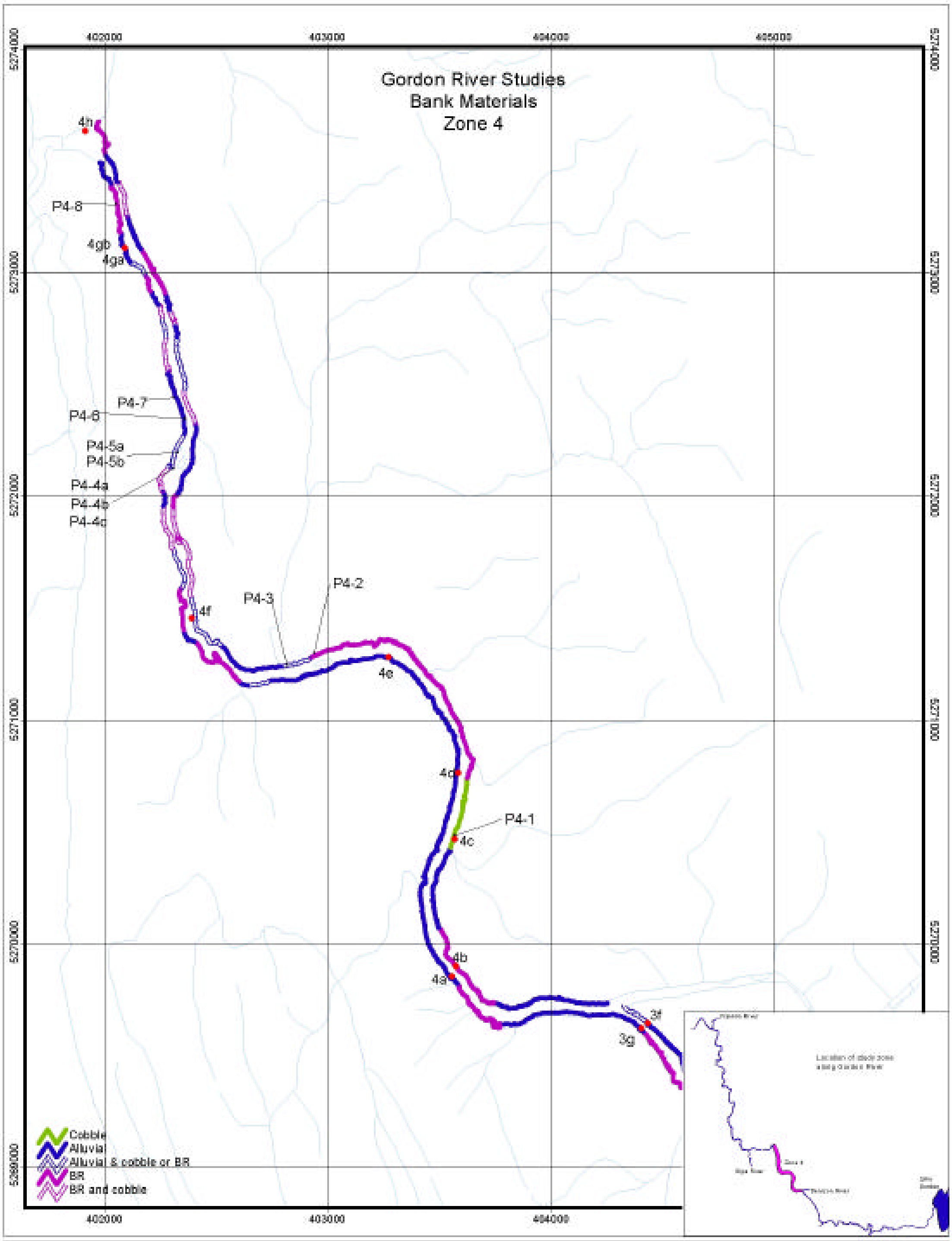


Figure 4.5. Map of the geomorphic monitoring sites (4a – 4h) and photo-monitoring sites (P4-1 to P4-8) in Zone 4 of the Gordon River, 2001-02.

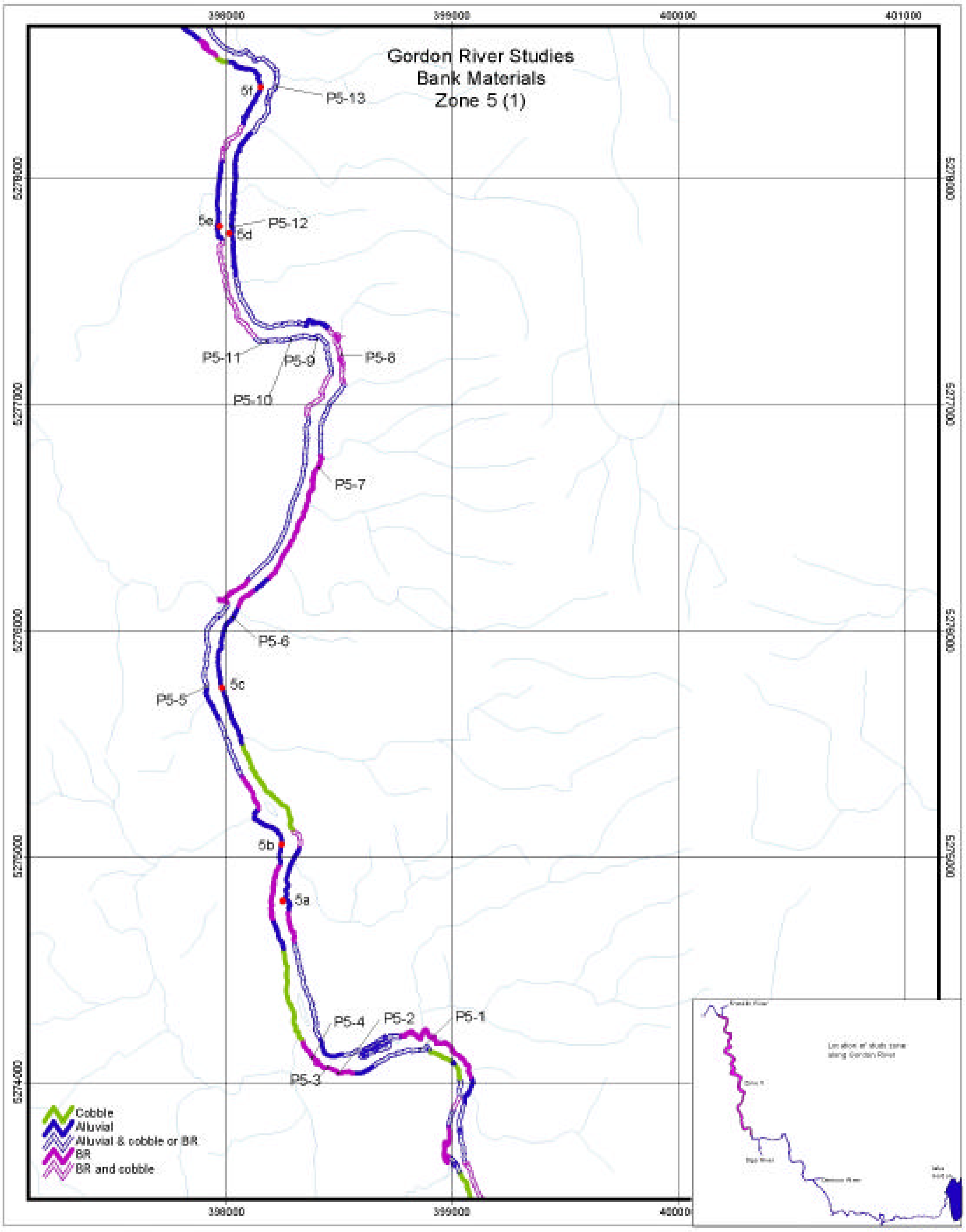


Figure 4.6. Map of geomorphic monitoring sites 5a – 5f and photo-monitoring sites P5-1 to P1-13 in Zone 5 of the Gordon River, 2001-02.

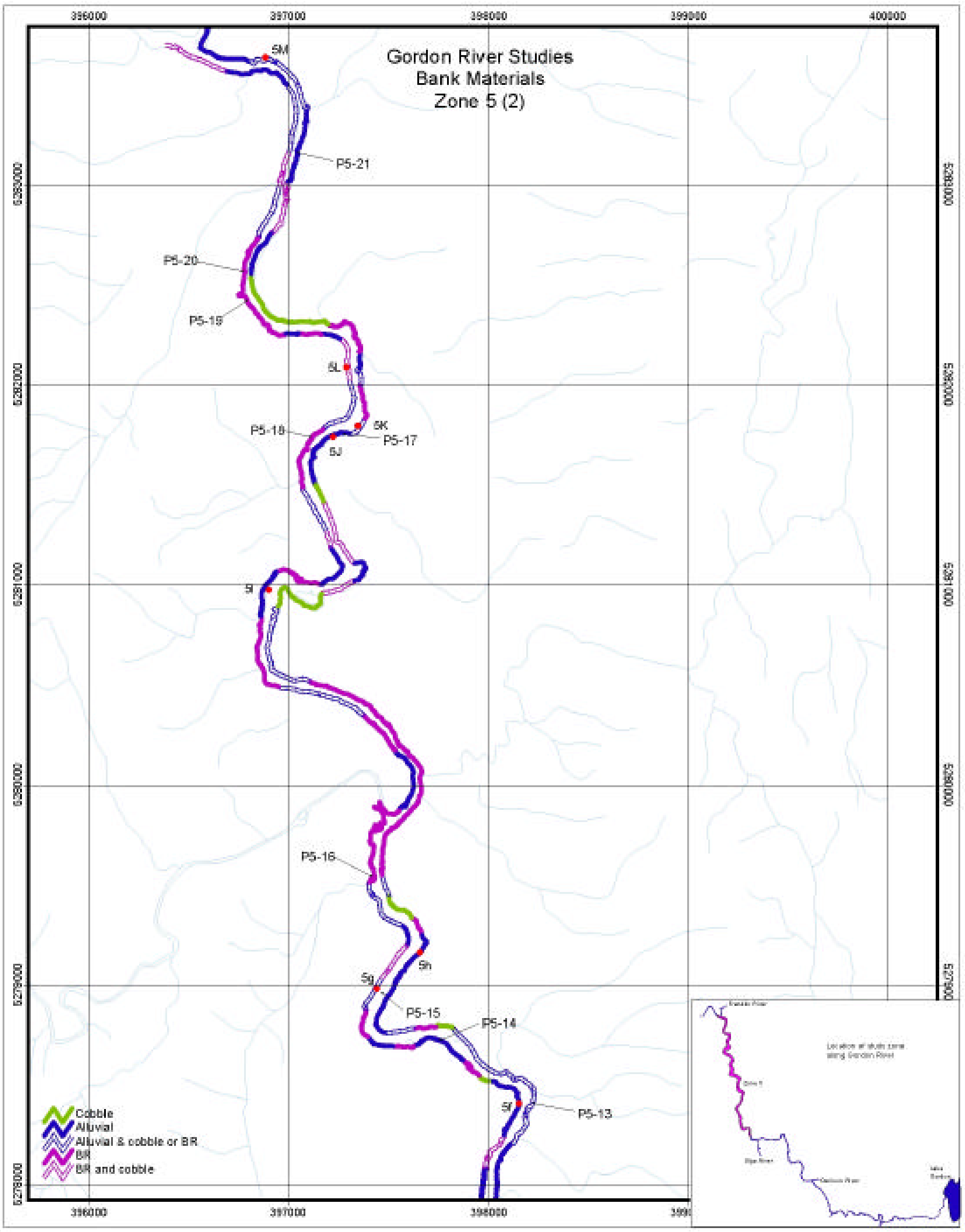


Figure 4.7. Map of geomorphic monitoring sites 5f – 5m and photo-monitoring sites P5-13 to P5-21 in Zone 5 of the Gordon River, 2001-02.

4.3 Hydrologic Overview

Figure 4.8, Figure 4.9 and Figure 4.10 show hourly discharge at the Gordon Power Station between 1 January 2000 and 15 February 2002, incorporating the Basslink study year (2000), and recent monitoring period (2001-02). The red arrows indicate dates when erosion pins were measured.

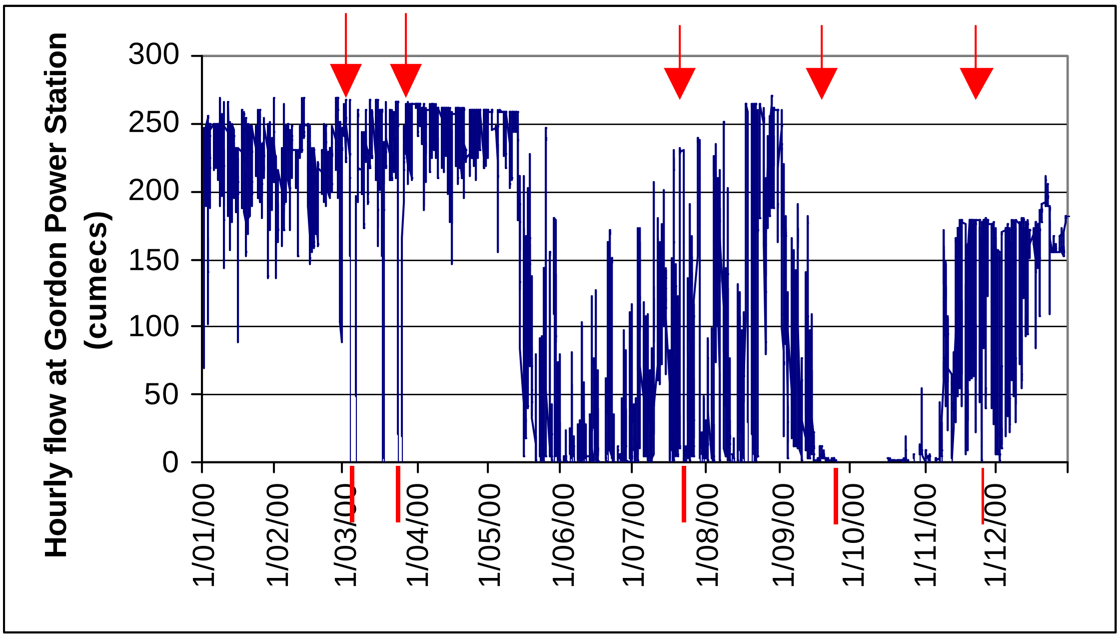


Figure 4.8. Hourly flow at the Gordon Power Station 1 Jan 00 - 31 Dec 00.

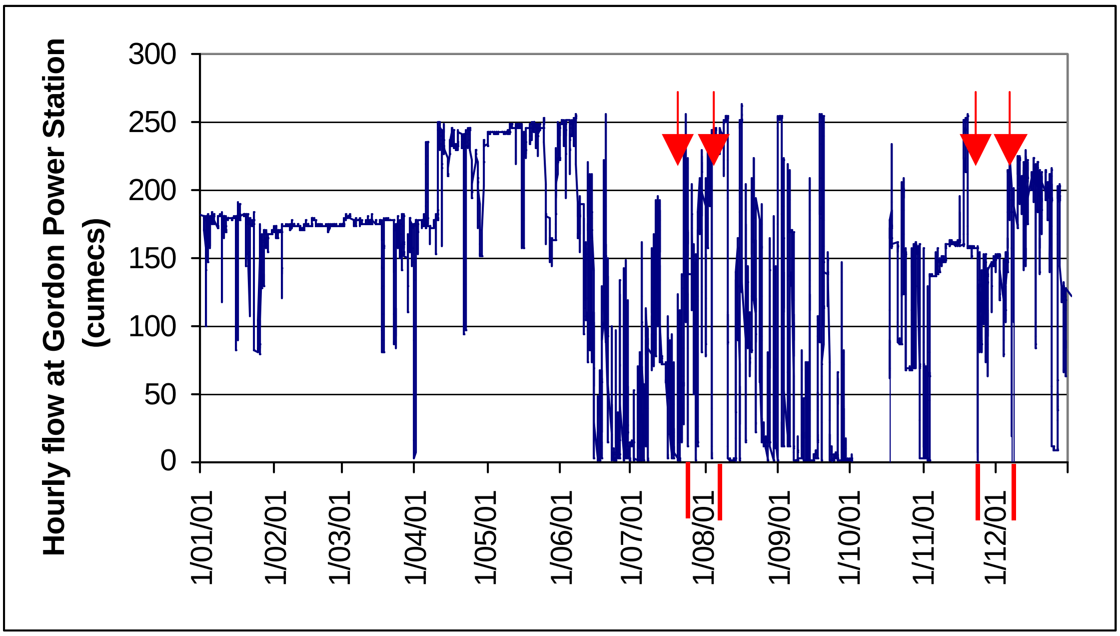


Figure 4.9. Hourly flow at the Gordon Power Station 1 Jan 01 - 31 Dec 01.

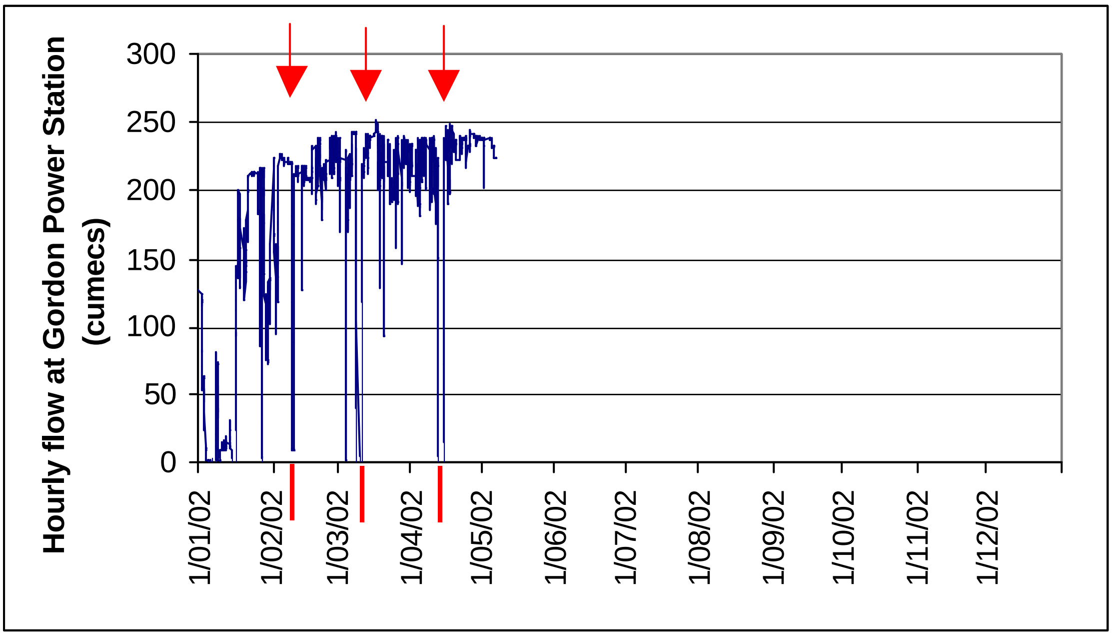


Figure 4.10. Hourly flow at the Gordon Power Station 1January 02 - 15 February 02.

The hydrographs show similar operational patterns at the power station for 2000 and 2001, with high flow in the summer months, when less water is available from other power schemes in the State, and generally lower flow during the rainy, winter months. There was a 3-month period in both 2000 and 2001 when the station was predominantly at 'full-gate', with flow exceeding 240 $m^3.s^{-1}$. To date, the 2002 hydrograph is similar to the first few months of 2000, with the station being run at or near full-gate levels. See Section 2.2 for a more detailed analysis of hydrology in the Gordon River for 2001-02.

Table 4.1 provides a comparison of flow between the initial Basslink study year, 2000, and 2001. During 2000, flow at the power station exceeded 210 $m^3.s^{-1}$ a greater proportion of time as compared to 2001, however, during 2001, three turbine (>170 $m^3.s^{-1}$) flow occurred for a longer cumulative duration. This is significant, because the Basslink findings suggested that much of the bank activity observed during the initial study year was related to the on-going adjustment of the middle Gordon River to 3-turbine power station usage, which had been limited prior to 2000. Based on the distribution of flow during 2001, it would be expected that this bank adjustment process continued.

Table 4.1. Percent of time flow at Gordon Power Station was less than 2 turbines (<150 $m^3.s^{-1}$), 3 turbines (>170 $m^3.s^{-1}$), and greater than 3 turbines efficient load (>210 $m^3.s^{-1}$), based on hourly flow records.

Year	<150 $m^3.s^{-1}$	>170 $m^3.s^{-1}$	>210 $m^3.s^{-1}$
2000	51	44	32
2001	39	49	20

4.4 Results

4.4.1 Erosion pins & scour chains

The number of erosion pin and scour chain measurements varied depending on when the site was established, and how often it had been measured. The short period of monitoring and limited number of data points is a very important consideration when viewing all of these results. All sites have a minimum of 2 measurements. Because the majority of the monitoring sites were established between November 2001 and February 2002, the results largely reflect summer conditions (high power station flows).

The results of erosion pin and scour chain monitoring are discussed in Section 4.5.1 of this report.

4.4.2 Peizometers

Peizometer results from Zone 2 are presented in Figure 4.11. The upgrading of the peizometer array was completed in December 2001, and results reflect summer flow conditions. Figure 4.11 also shows the corresponding river level heights for various power station operating modes.

The peizometer results show a discrepancy between river level (red) and probes 2 – 5 in Figure 4.11. Above river level 3.27 m the river level probe and probe 2 should record the same water height, as both are submerged by the river. The similarity in water level between probe 2 and probes 3 – 5 following prolonged periods of inundation suggests that these four probes are responding consistently, and the river level probe is reading high. Following the period of full-gate power station operation between the 6th and 8th of March 2002, the difference between river level and probe 2 is 16.5 cm. The cause of this discrepancy is unknown and is being investigated. Peizometer results are discussed in Section 4.5.2.

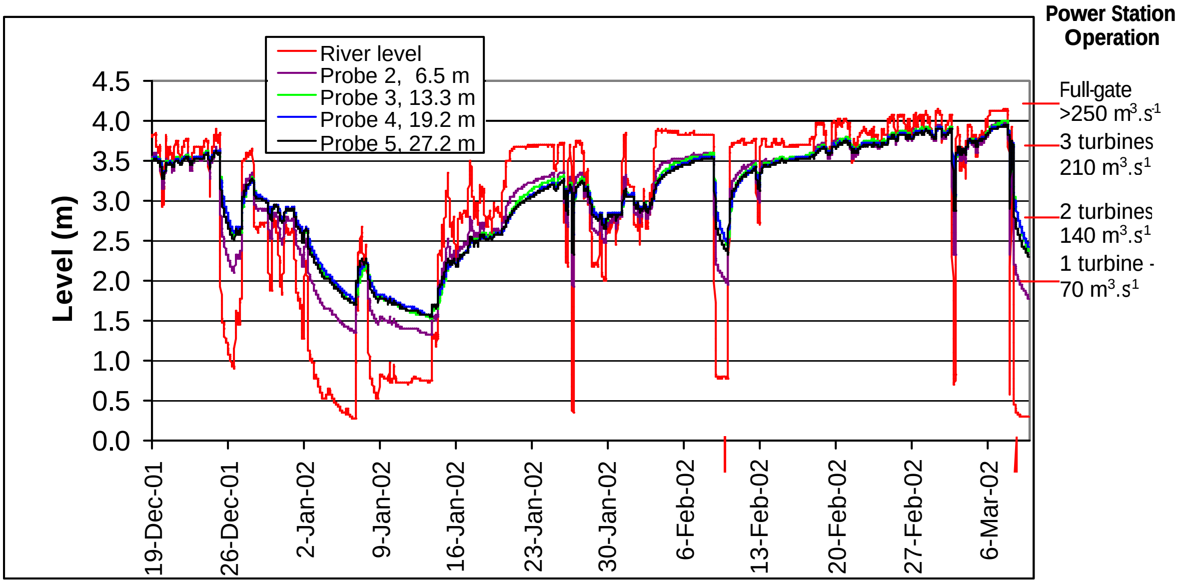


Figure 4.11. Peizometer results from Zone 2 peizometer site.

4.4.3 Photo Monitoring

As this is the first photo-monitoring campaign, no comparisons with previous photos are presented or discussed in this report, but will be provided in future monitoring reports.

4.5 Discussion

The majority of monitoring sites in the middle Gordon River have been established only recently and results reflect a few months of summer flow conditions. Analysis of results in any meaningful way is prevented by this short time period and limited number of data points. Based on this limited data set, trends can be noted, but a longer monitoring record will be required to accurately quantify processes operating in the middle Gordon, and to identify links with power station operation. In the following discussions, broad trends are identified, and comparisons are made between the recently collected data and the findings of the Basslink geomorphology investigation (Koehnken *et al.,* 2001). The results from the erosion pin and scour chain monitoring are discussed for each zone, followed by a discussion of the peizometer results. A synthesis of the discussion is presented in Section 4.5.3.

4.5.1 Erosion pins and scour chains

The erosion pin results varied significantly within and between sites and zones. In general, the monitoring results indicate that during the summer, when flows have been high and include long periods of continuous power station operation, scour of the toes of sandy banks is common and widespread in the study area, with the remainder of the bank showing far less change. Banks affected by seepage erosion were found to be active: the erosion pin and scour chain results were consistent with the downslope movement of material on the bank, including the removal of material from the back walls of cavities. Each zone is briefly described in the following sections.

4.5.1.1 Zone 1

Zone 1 has 6 erosion pin sites, including one relatively long-term site established in December 1999 (Site 1A). The remaining sites have been monitored 3 times over a 6-month period. The long-term site (Site 1A) is located in a colluvial bank adjacent to a left bank cobble bar. Most of the pins are placed horizontally in the vertical bank face and create a longitudinal transect spanning 70 m. Figure 4.2 shows the location of the erosion pins in this zone.

The pins show a range of responses, with most pin measurements showing some variability, but little nett change within the error of measurement associated with the long-term sites. Two exceptions were noted, but these results reflect the movement of soil material around the pin, rather than fluvial deposition. The two scour chains at Site 1A, located near pins 1A/1 and 1A/4 have shown less than 1 link of change since installation.

At the other sites in Zone 1, the greatest level of activity is associated with pins located in cavities (1D pin 1; and site 1F, all pins).

The alluvial banks without cavities (1C = series of pins along the bank toe; 1E = profile up a bank slope) show minor deposition or little change. A scour chain was installed at Site 1E in March 2002, but has not been revisited for measurement.

Figure 4.12 shows erosion pin results from sandy bank toes in Zone 1, indicating that there has been minor deposition or erosion throughout the zone. This relative stability is probably related to the underlying cobbles or bedrock present throughout the zone.

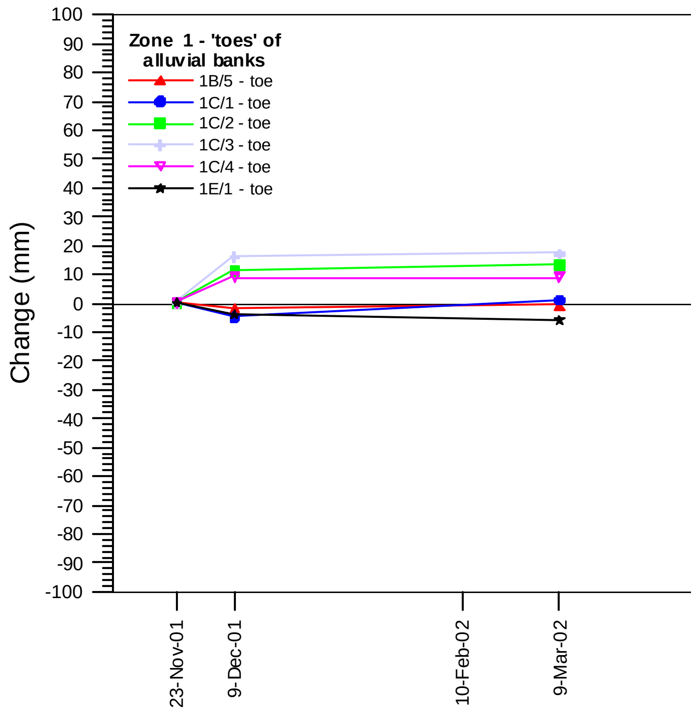


Figure 4.12. Erosion pin results from bank toes in Zone 1.

4.5.1.2 *Zone 2*

Over the 2001-02 monitoring period, Zone 2 appeared to be the most active zone, based on field observations. This was consistent with the investigations reported in Koehnken *et al.* (2001). The 12 erosion pin sites in Zone 2 showed a range of responses but were generally very dynamic, with large changes documented at both the long-term sites and the recently installed sites. Six sites were installed in November 1999, and provided a reference which indicated that the scale of changes documented at the new sites was consistent with the longer term observations. Figure 4.3 shows the location of the erosion pins in this zone.

Zone 2 has the highest proportion of sandy alluvial banks in the study area, and the bank materials tend to be more micaceous as compared to the other zones. Water level fluctuations due to power station operation were high in this zone (~4 m), and the Albert River is the only significant tributary entering the zone (see Figure 4.1).

In general, sites characterised by bank cavities and sediment flows (2B, 2C, 2E, 2G, 2H, 2K) showed sediment movement consistent with the downslope movement of material derived from the collapse of bank walls. At these sites, deposition on bank slopes and erosion in cavities of up to 100 mm has been documented over the recent summer months. Some of the sediment movement at monitoring sites may have been the result of a vegetation sampling near the site prior to the measurement of the pins.

The alluvial banks without cavities (2A, 2D, 2I, 2J 2K, 2L) tended to show erosion of the bank toe, with decreasing erosion upslope. The scale of these changes varied considerably. At Sites 2A and 2I which have low slopes and are vegetated by tea-tree, changes were on the order of millimetres. Erosion on the scale of centimetres has been recorded on steeper banks that show evidence of downslope mass-movement, even in the absence of distinct cavities (2D, 2J).

Site 2F consisted of two pins driven into the face of a vertical cobble bank. The data indicated erosion for both pins. However, this was due to local scour around the base of the pins that has resulted in the loss of gravels from the bank. The surrounding bank face has not experienced a similar change over the same time period.

 shows erosion pin results from bank toes in Zone 2. Erosion at the long-term site 2L is characterised by one major event followed by relative stability. The other sites generally showed a combination of deposition and erosion, with nett erosion the general trend.

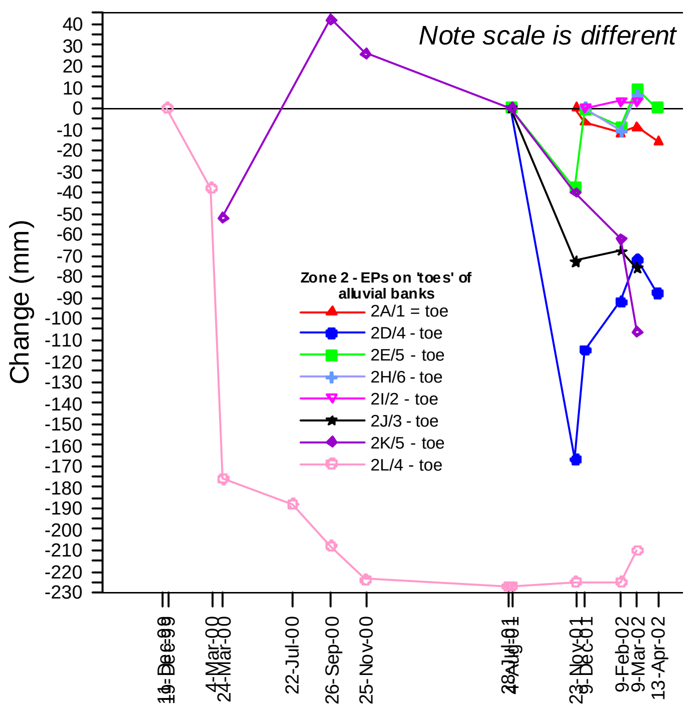


Figure 4.13. Erosion pin results from bank toes in Zone 2.

Scour chains are located on the mid-bank slope at sites 2A, 2D, 2K and 2L. Site 2A has only a three-month record, whereas the other sites were installed in December 1999. No change has been recorded at Site 2A. At Site 2D, the overall trend was depositional, due to the movement of material downslope. At site 2K, there was nett erosion of 9 links, although not continuous, with deposition from the downslope movement of material at times burying the chain. Results from Site 2L showed two links were exposed since December 1999, with no periods of deposition.

4.5.1.3 Zone 3

Figure 4.4 shows the location of the erosion pins in Zone 3. Of the eight monitoring sites in this zone, only one (3A) is a long-term site. Site 3A consists of a star-picket in a bank toe and has indicated consistent erosion since installation in December 1999. A total of 380 mm change has been recorded at the site, which is consistent with results from a scour chain installed a few metres downstream of the star picket. There, eight links (235 mm) have been exposed during the same time period, without any evidence of depositional episodes (i.e., the scour chain is always fully exposed).

Immediately downstream of 3A, Site 3B is characterised by cavities and sediment flows and has also shown a high level of activity. Although Site 3A appears to be a ‘new’ site, pins were originally installed in December 1999. However, the level of activity has resulted in the disappearance of most of the pins due to bank collapse and downslope movement of bank material, and the site required re-installation in November 2001.

Similar to Zone 2, the sites in Zone 3 installed in, and downslope of, cavities (3C, 3F) had high variability. Site 3Ea is a ‘V’ formation of 5 pins installed in a small gully. The data indicated the collapse of one of the downstream gully walls (pin 3Ea/5), with deposition downslope (pins 3Ea/3, 3Ea/4).

Other sites generally showed erosion of bank toes, with erosion decreasing with distance upslope. Figure 4.14 depicts erosion pin results from all of the bank toes monitored in Zone 3. Unlike Zones 1 and 2, the results were fairly consistent, with all except one site showing erosion of between 30 mm and 80 mm, similar to the trend documented at the long-term Site 3A. Site 3D, which showed minor deposition may be reflecting activity of the upslope cavity.

Scour chain results were consistent with the erosion pin results. At sites showing erosion of bank toes, without active cavities upslope, scour chain results indicated either erosion or no nett change. At Site 3A, a total of eight links had been exposed since installation in December 1999. Two links have been exposed at the recently installed chain at site 3Eb, and there has been no nett change at Site 3G. The active sediment flows at Site 3B resulted in deposition on the scour chain of between 30 mm and 190 mm, with no nett erosion.

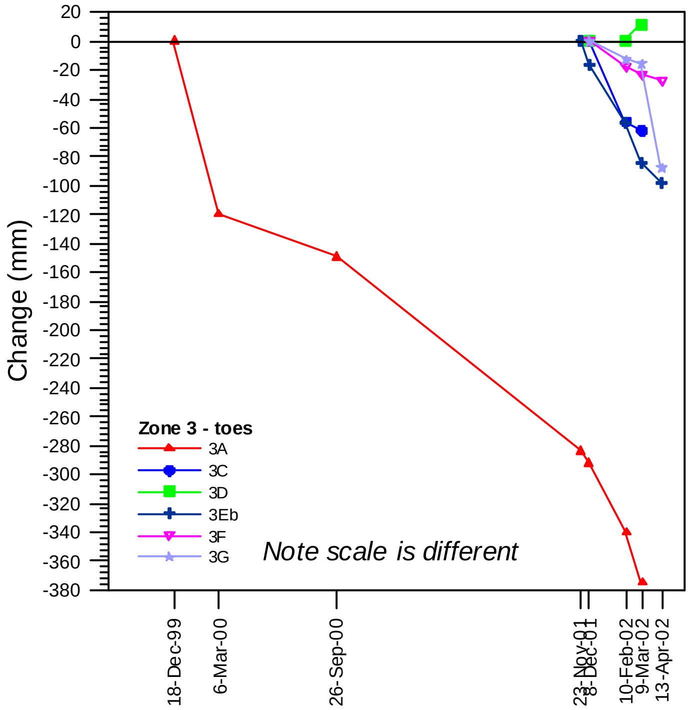


Figure 4.14. Erosion pin results for bank toes in Zone 3.

4.5.1.4 Zone 4

Figure 4.5 shows the location of the erosion pins in Zone 4. The results from this zone typically show erosion of the bank toe with smaller changes upslope, consistent with the upstream zones. A major difference is that whereas large cavities are common in Zone 2, and occasional in Zone 3, they are largely absent in Zone 4. Consequently, erosion pin results do not reflect the downslope movement of sand due to seepage erosion. The one long-term site in the Zone (4F) shows little change between December 1999 and the start of the recent monitoring, however the sampling frequency was very low, and the recent results suggest that there is a great deal of variability over shorter time scales. Results from the recently installed 'toe pins' at this site indicated erosion over the summer months.

In the erosion pin results from all bank toe monitoring sites in Zone 4 are presented, showing a general trend towards erosion. The range of change, ~30–120 mm over the November 01 to March 02 period, was similar in magnitude to that observed in Zone 3.

With the exception of Site 4F, scour chains have only been installed for a few months and have shown little change apart from a dusting of sand at some sites. Since installation in December 1999, the chain at Site 4F has indicated erosion, with 1 link exposed.

Site 4C consists of two pins installed in a vertical cobble bank and, similar to Site 2F, local scour has occurred around the base of the pins. Some variability in the results is also attributable to the irregular contact between the pin and the gravels, making measurement difficult.

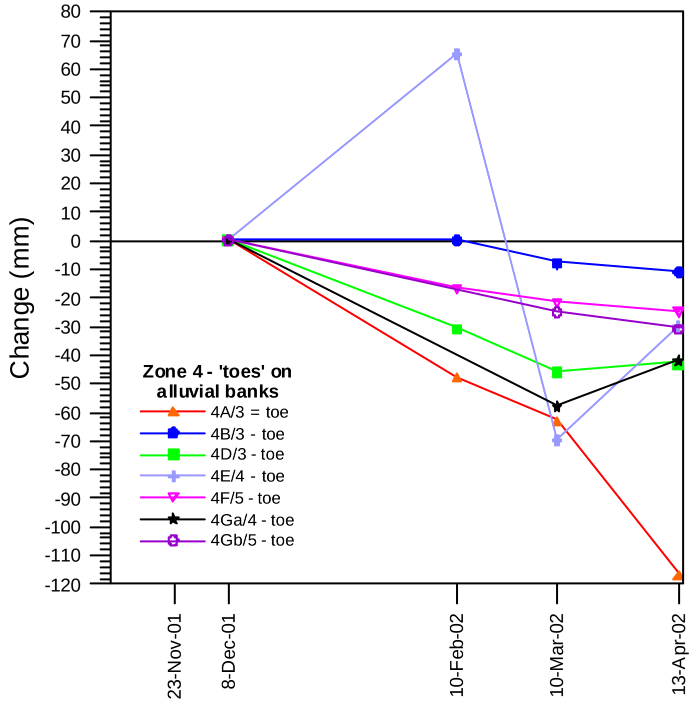


Figure 4.15. Erosion pin results for bank toes in Zone 4.

4.5.1.5 Zone 5

The results from the 13 monitoring sites in Zone 5 were generally consistent with upstream trends, but changes were typically on a smaller scale. Similar to Zone 4, there was little evidence of seepage erosion induced sediment flows. The one site established near a cavity (5E), however, showed changes over the entire bank face with the results similar to the upstream sites (erosion of cavity, deposition on slope, erosion of toe). Figure 4.6 and Figure 4.7 shows the location of the erosion pins in this zone.

The one long-term site in the Zone (5G) showed consistent changes since December 1999, although sampling frequency has been very low. The upper slopes and pins placed behind LWD showed deposition, whereas pins in the lower slope and toe of the bank have recorded material loss.

Figure 4.16 shows the erosion pin results from bank toes in Zone 5; although most sites showed erosion, there was a wide range of responses, with the slopes of the recent monitoring sites varying considerably. With the exception of Site 5A, changes were less than 30 mm.

Scour chains were installed in Zone 5 in February and March 2002, and have been monitored only once. The sites are generally located on the mid-bank slope and so far have not recorded any deposition or erosion. The chain at the long-term site, 5G, has shown nett erosion with 3 links exposed since December 1999, with no depositional periods.

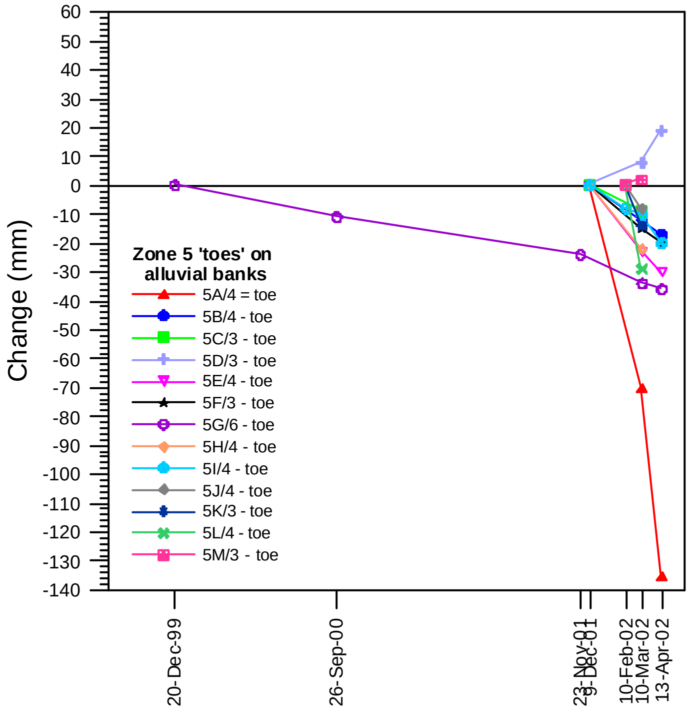


Figure 4.16. Erosion pin results from bank toes in Zone 5.

4.5.2 Peizometer results

The peizometer results showed that the high usage of the Gordon Power Station over the summer months has resulted in long-durations of elevated water levels in the banks. Water levels at all probes were generally equivalent to river level for much of the monitoring record (assuming river level is equivalent to probe 2 at high flow). Since January 15th, relative water levels in the banks have exceeded two metres with the short power station shutdowns insufficient in duration to allow bank draining. The water level movement within the bank was consistent with previous observations; in-bank water levels rapidly responded to river level changes, and were evident at distances of 20 m and more inland.

The saturated bank conditions recorded by the peizometers were consistent with the active seepage erosion observed during power station shutdowns, and the erosion pin and scour chain results that indicated a high level of activity at sites where cavities and sediment flows were present. Bank responses to water level changes were consistent with those reported in detail in Koehnken *et al.*, (2001).

4.5.3 Synthesis of monitoring data

The recent monitoring period (November 01 – March 02) has been characterised by high power station usage, including prolonged periods of 3-turbine and full-gate operation. Local rainfall and associated natural inflows have been low, so flow in the entire study reach has been dominated by discharge from the power station.

The erosion pin and scour chain results indicate scour of bank toes is occurring throughout the study reach, with seepage erosion processes very active in the reaches upstream of the Denison River. Erosion decreases with distance upslope, with upper banks showing little change over the short monitoring period. These trends are consistent with the findings of the Basslink Geomorphology investigations which related bank toe scour to increased use of 3-turbines in the power station, and seepage erosion to saturated bank conditions and rapid draw-down. In general, the hydrology of the recent monitoring period has been very similar to the summer portion of the 2000 Basslink study year, and the erosion pin, scour chain and peizometer data reinforce the premise that the middle Gordon River is still actively adjusting to 3-turbine power station operation.

There is a large degree of variability within and between the zones, with Zone 1 monitoring sites showing relatively less bank toe scour as compared to the downstream reaches. This is likely to be attributable to the widespread buttressing of bank toes by bedrock and cobbles in the zone.

The Zone 2 sites showed a high level of activity, with bank toe scouring and the downslope movement of bank material through seepage processes resulting in deposition and scour, sometimes at the same site. This Zone has the highest proportion of alluvial banks in the middle Gordon River and experiences large (~4 m) water level fluctuations associated with power station operation. It was identified as the most active zone in the Basslink investigations and the monitoring results indicated this was still the case.

Downstream of Zone 2, scour of bank toes appeared to be the dominant process, with the number of sites dominated by seepage erosion processes decreasing, especially downstream of the Denison River. In general, the magnitude of bank toe scour also decreases with distance downstream.

More measurements are required, and specifically during the wet winter months, before an in-depth analysis of the relationship between power station operation and erosion in the middle Gordon River can be completed. A fair understanding has been gained, during the past 2-years, of how summer power station operation during drought conditions affects bank stability. However, there is a poor understanding of how winter flows affect banks. Field observations during winter months suggest that seepage processes are less active with the banks in Zone 2 appearing more stable. Trends at two of the long-term erosion pin sites, 2K and 3A, suggest that winter processes may result in reduced erosion rates (3A, Mar 00 – Sept 00) or even deposition (2K, Mar 00 – Sept 00). These findings highlight the need to collect data over a range of summer and winter flow conditions.

The present monitoring sites provide good information about the erosive processes operating in the middle Gordon River.

5 Karst Geomorphology

Key karst features are monitored in both the Gordon-Albert and Nicholls Range karst areas twice per year. During 2001-02, monitoring trips occurred in December 2001 and March 2002. An additional monitoring trip was conducted in November 2001 to survey the Gordon-Albert karst area and install monitoring equipment.

Figure 5.1 shows the location of the two karst areas investigated by the monitoring program.

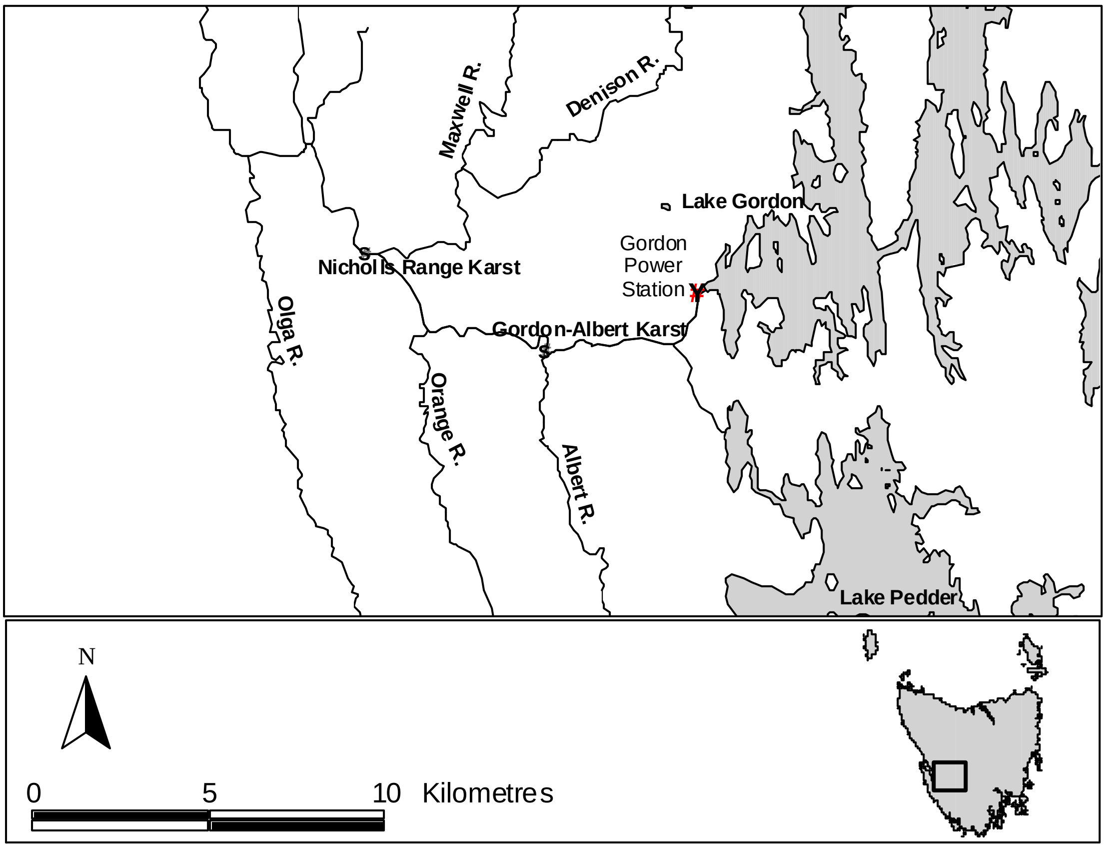


Figure 5.1. Map of the locations of karst monitoring sites in the Gordon River during 2001-02.

5.1 Gordon-Albert karst area – November 2001

5.1.1 Monitoring sites

There are 4 karst monitoring sites in the Gordon–Albert Karst area, all of which can be accessed from two points in the river. Site 1 is a backwater channel known as Channel Cam, Site 2 is the new cave (GA-X1) with a doline at the entrance, and Sites 3 and 4 are dolines. Each site has a number of 6 mm diameter 316 stainless steel erosion pins installed and a photo-monitoring site marked with a red metal peg.

5.1.2 The new cave (GA-X1)

A new cave was found in the Gordon-Albert karst area, which was designated as GA-X1. The cave is 28 m long (including the large entrance area), 10 m deep, and is located approximately 10–20 m from the Gordon River. There are two entrances to the cave: the smaller entrance lies on the western (river) side of the feature and is a short near-vertical shaft leading down into the main chamber; the second entrance is much larger and is effectively the base of a second large doline. The cave has a sump at its lowest level, which is (within the level of accuracy of the survey) at the same level as the Gordon River.

In November 2001, there was evidence of flood debris (small twigs and leaves) on the walls of the cave, which is 3–4 m above the level of the sump. This level is consistent with the range of fluctuations of the Gordon River in this area based on the water level recorder at site 71. The lower portions of the cave were also encrusted with mud, which suggests recent flooding.

Continued, repeated fluctuation of the river may draw sediment out through the sump at the bottom of the cave, thereby destabilising the sediments on the cave floor and at the entrances, potentially leading to collapse of the surrounding vegetation. Doline collapse is a normal karst process but the primary Basslink management issue is whether the expected increased number of river fluctuations would significantly alter the natural process.

Erosion pins were installed into the sediments in the cave, doline and a nearby doline. With these, and regular photo-monitoring, the karst monitoring program will continue to learn more about the sediment transport processes through the system. The low energy environment in this cave (apart from the lower levels subject to flooding) suggests that the most significant influence on sediment transport will likely be from human visitation to read the erosion pins.

5.2 Nicholls Range karst area – December 2001

5.2.1 Monitoring sites

There are two karst monitoring sites in the Nicholls Range Karst area, Site 5 in Kayak Kavern and Site 6 in Bill Neilson Cave. Both sites were accessed by boat.

Kayak Kavern has 4 erosion pins installed and a photo-monitoring site marked with a red metal peg. Bill Neilson Cave site has 5 sub-sites within the cave which are designated 6A–E. Sub-sites 6A–C comprise various arrays of erosion pins. Sub-sites 6D and 6E are two lightweight capacitive water level probes. Water levels were recorded every 20 minutes over a range of 1.0 m.

All pins and pegs are flagged with yellow fluorescent tape.

5.2.2 Kayak Kavern and Bill Neilson Caves

Since the previous trips to Kayak Kavern in August and September 2000, the following changes have been noted:

- The 0.1 m mound on the top of the silt bank was not present on 8th December 2001.
- New large branches and logs had washed up on the silt bank at the entrance.
- The beach at the entrance of the cave appears to have changed shape. It has become less steep and has retreated towards the back of the cave by a couple of metres.
- A small scarp (~0.2 m) had formed in the silt beach approximately 0.3 m from the original erosion pin. There was associated cracking in the sediment and the pin had tilted slightly forwards towards the water.
- The original erosion pin had changed in height from 325 mm measured on 2nd September 2000 to 309 mm which would suggest that sediment has been deposited. However this is not a conclusive result as there was only one sample point.

There was also evidence of change in Bill Neilson Cave as follows:

- Recent inundation by Gordon River water had been to lower levels than had been observed in 2000. While the inundation marks were not accurately recorded, the newly installed water level recorder should provide this information in the future.
- Several new logs and branches had fallen into the cave through the daylight holes. Three of the four water level recorder stakes, which had been installed as rudimentary water level recorders, had been knocked over by falling debris.
- The remaining stake, which was the one closest to the floor of the cave, showed a definite ‘clean zone’ at approximately 0.89 RL where the soluble paint had been washed off. The paint was still visible above this line and also on the other three stakes. This suggested that water levels had not reached more than 10 cm higher than observed in 2000, in the interim 15 months. This equates to an inundation distance of approximately 200 m into the cave.

5.3 Both karst areas – March 2002

5.3.1 Erosion pin data

The erosion pin data for all sites are summarised in Table 5.1.

There was clear evidence that some of the pins had been interfered with by either animals or birds, particularly in the dolines at Sites 3 and 4 where the pins are relatively accessible. The yellow fluorescent tape around the tops of the pins had been chewed and, in the case of pin 5, had been completely removed. There had also been some interference in Bill Neilson Cave at the second wet sediment bank, where the tape on the pins above the water level had been chewed. It was interesting to note that the tape in the adjacent wet sediment bank, and in Kayak Kavern, had not been touched.

Table 5.1. Erosion pin data for karst geomorphology monitoring sites for 2001-02.

Site no.	Site description	Pin no.	Length at 23/11 or 8/12/01 (mm)	Length at 9/3/02 (mm)	Change (mm)	Condition of tape	Preliminary interpretation
1	Channel Cam	1	322	318	–4		Deposition?
2	GA-X1 cave	2	250	239	–11	clean	Deposition?
		3	190	189	–1	clean	No change?
		4	154	161	+7	muddy	Erosion?
	Doline at cave entrance	9	214	213	–1	clean	No change
		10	278	278	0	clean	No change
3	Doline adjacent to GA-X1	5	259	287	+28	gone	Interference
		6	300	300	0	clean	No change
		7	254	252	–2	clean	No change
		8	195	196	+1	clean	No change
4	Small doline	12	192	171	–21	chewed	Interference
		13	234	238	+4	chewed	Interference
		14	253	256	+3	chewed	Interference
5	Kayak Kavern	16	309	308	–1	muddy	No change?
		17	293	291	–2	muddy	Deposition?
		18	267	266	–1	muddy	No change?
		19	249	245	–4	muddy	Deposition?
6	Bill Neilson: 6A at entrance	20	483	480	–3	muddy	Deposition?
		21	300	299	–1	muddy	No change?
		22	272	272	0	clean	No change
	Bill Neilson: 6B Sed bank II	25	194	195	+1	muddy	No change?
		26	203	203	0	clean/chewed	No change
		27	215	216	+1	clean/chewed	No change?
	Bill Neilson: 6C Dry sed bank	23	297	297	0	clean	No change
		24	227	226	–1	clean	No change?

Note that in the caves, smaller changes in erosion pin heights can be regarded as more significant than in the dolines as the substrate is fine sediment and measurements can be made reasonably accurately. The substrate in the dolines is leaf litter and twigs which is more unstable and therefore readings are less accurate.

5.3.2 Water level recorders

The hydrographs from the two water level recorders in Bill Neilson Cave, between 8 December 2001 and 9 March 2002, are shown in Figure 5.2. The flow in the tailrace at the power station over the same period is also shown, for comparison.

5.3.3 Photo-monitoring

Photos were taken at all photo-monitoring sites as planned. A portfolio for each site is being assembled.

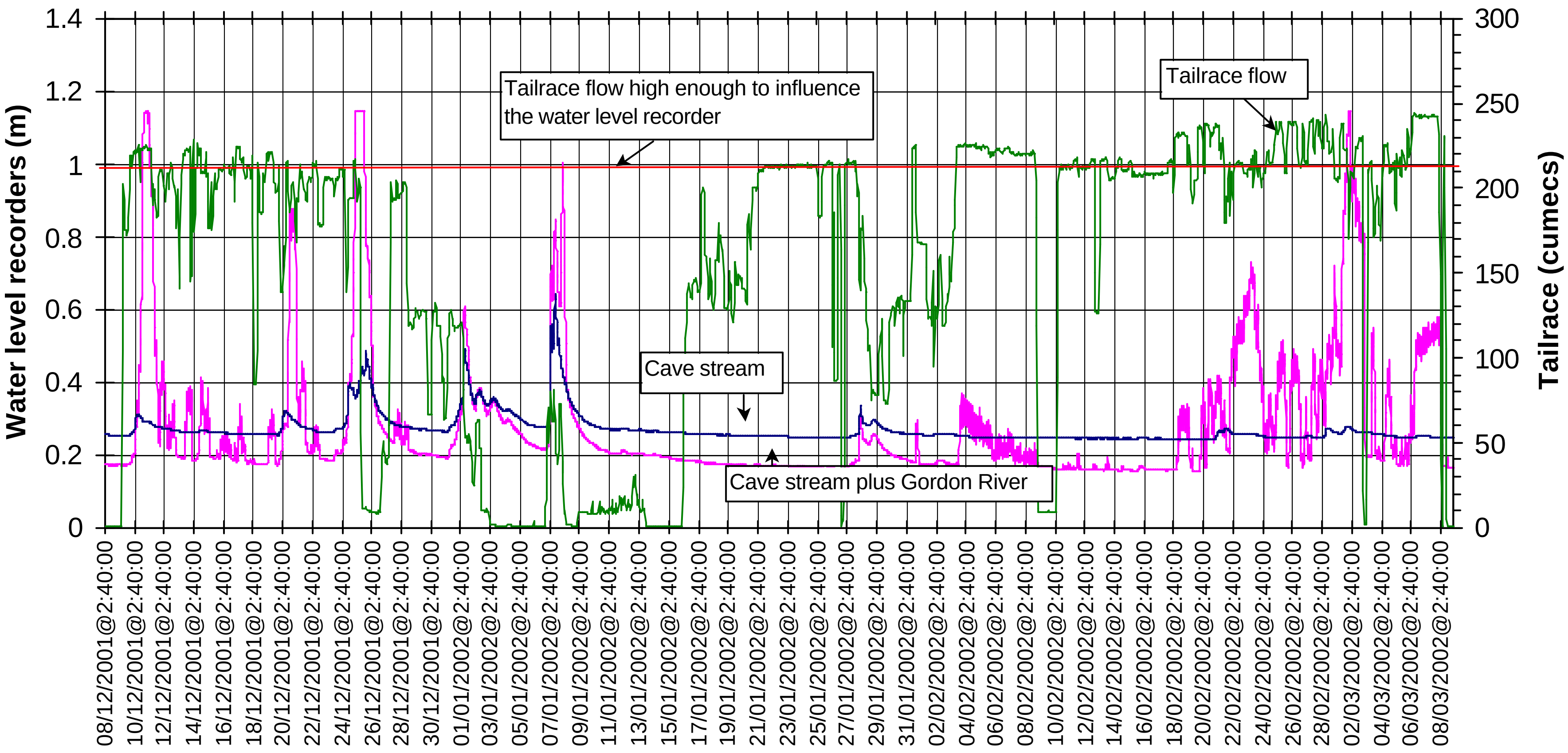


Figure 5.2: Water level data from Bill Neilson Cave,and power station tailracedischarge. During the relatively dry prevailing conditions, the recorder was not inundated until the power station was releasing more than approximately 210 cumces. The effects of high flows in the Denison River have not yet been isolated.

5.4 Discussion

5.4.1 Erosion pins

All results presented are based on limited data collected between December 2001 and March 2002, and should be considered very preliminary.

5.4.1.1 Bill Neilson cave

The erosion pin data suggest that, overall, there appears to be little nett sediment movement in Bill Neilson Cave. The sediment closest to the floor of the cave appears the most mobile, which is to be expected as it is also influenced by the cave stream processes.

The data indicate that there may have been some deposition in the cave, although the maximum change in pin height (pin no. 20) was only –3 mm. It would appear from the very limited data so far that, over the longer term, there may be a nett balancing of deposition and erosion, as pin no. 20, which was installed on 4th September 2000, has had a nett change of zero mm in 18 months.

5.4.1.2 Kayak Kavern

The pins in Kayak Kavern corroborated the results from Bill Neilson Cave. The maximum sediment displacement on the pins was –4 mm on pin no. 19. This pin is protected in an eddy in the cave and so a larger change in pin height relative to the other pins could have been anticipated. Pin no. 16, which has been in place since 2nd September 2000, showed little change (–1 mm). While this pin has had a change of –17 mm over 18 months, it is important to note that there is evidence of some displacement since it was originally installed.

5.4.1.3 GA-X1

The pin array in the new cave in the Gordon-Albert karst area had a range of results. Pin 4, which is the pin closest to the lower level sump, has increased in exposed length by 7 mm. Pin no. 2, which is located further back into the cave and at a higher level, has shown a decrease in pin length of 11 mm. These results, combined with the sediment flow patterns on the cave floor and the mud on the tape at pin 4, suggest that sediment may be moving through the cave from the smaller upper level entrance, and out through the sump at the bottom. Further analyses will be possible when the water level recorder data have been obtained next season.

5.4.1.4 Dolines

Changes of up to +28 mm have been observed in the erosion pins located in the dolines. However, all of these relatively large changes have been recorded from pins which show evidence of some interference. Pins which have not been affected have recorded changes of –2 mm to +1 mm which indicates that there had been little to no appreciable sediment movement to date. It is anticipated that the 12-monthly survey of the pin arrays should provide more useful information, than this 4-month measurement interval of individual pin lengths.

There are significant differences in the sensitivity of the pin measurements between sites which must be considered in analysing the results: pins inserted into a fine sediment base, such as those in the caves, can be much more accurately measured than the doline sites where the pins are inserted through vegetation and leaf litter. These differences in error margins of measurement need to be considered in determining whether actual changes have occurred.

5.4.1.5 Channel Cam

The erosion pin in Channel Cam has changed by –4 mm suggesting that deposition may be occurring in this area. The original survey of the channel showed that the base of the depression was inundated when the water level at site 71 was approximately 4.1 m (or between 225 and 230 cumecs of flow in the tailrace in dry weather). Based on the hourly water level recordings at site 71, this area was inundated for less than 9 full days (8.7 days) between 23rd November 2001 and 9th March 2002, which suggests an average deposition rate of almost 0.5 mm per day.

5.4.2 Water level monitoring in Bill Neilson cave

The data from the water level recorders in Bill Neilson cave are shown in Figure 5.2, together with the flow at the tailrace over the same period. The effects of the Gordon River water on the cave stream can be clearly seen in the data when the two hydrographs are compared. In relatively dry weather, the Gordon River water only affects the water level recorder, which is located approximately 130 m into the cave, when the power station is releasing more than 210 cumecs.

By isolating periods when the cave stream level was low, the maximum fluctuation in water level due to the effects of the power station alone was estimated to be 0.45 m (between 0.15 m and 0.6 m on the gauge). This suggests that, in dry weather, a power station output of up to 240 cumecs causes the water level in the cave to rise to a height of approximately 0.56 mRL. This indicates that, at least during the summer months, the dry sediment bank 175 m into the cave is unlikely to be affected by power station operations.

The highest peaks in the hydrograph corresponded to rainfall events rather than the effects of the power station but the data series is not yet long enough to determine the effects of the station combined with a heavy rainfall event and high flows in the Denison. The effect of high flows in the Denison River are likely to be significant and this will be assessed as the winter flow data become available in conjunction with the new cave survey data.

5.4.3 Photo-monitoring

The photo-monitoring has so far, not revealed any additional information that had not already been gleaned from direct observations.

6 Riparian Vegetation

6.1 Monitoring Strategy

The riparian vegetation monitoring program aims to investigate current condition and processes on the middle Gordon River and relate these to potential future changes in power station operation. Each year data will be collected to allow both spatial and temporal comparisons. Data collected will enable detection of changes occurring within the Gordon River system both pre- and post-Basslink. Variations between the Gordon River and the Denison and Franklin Rivers will allow spatial comparisons between the affected and reference rivers.

6.2 Methods

This monitoring program collected data on the cover and abundance of the existing vascular riparian species at permanent plots located in the middle Gordon River and in two reference rivers. The Franklin and Denison Rivers are included in the monitoring program as reference rivers to control for regional variables such as drought and recruitment events over the duration of the monitoring program.

The monitoring comprised two methods of assessment: permanent quadrat sites and photo-monitoring sites.

6.2.1 Quadrat sites

Permanent quadrat sites have been established and measured at areas of high disturbance to focus on recruitment and loss of keystone species, as identified by Davidson and Gibbons (2001). Quadrat sites were located along riverbanks in a design stratified to select sites prone to high levels of disturbance, and on vegetated cobble bars. This method will enable more rapid detection of any changes to the riparian vegetation as a “worst case” scenario. This bias has resulted in a majority of the permanent quadrat sites being located on the active alluvial river banks.

Within the Gordon River all bank sampling sites corresponded with sites established for geomorphology monitoring. One of the primary considerations in site selection was long term stability of the quadrats. In areas of overhangs or very active scour, vegetation monitoring sites have been located nearby.

Bank sampling sites have been established in four of the five geomorphology zones of the Gordon River (see Figure 4.1, Zones 2-5). No bank sites were established in Zone 1, the zone closest to the power station, due it being dominated by bedrock substrate. Cobble bar sites were selected on the basis of having some shrub cover and being partially or totally inundated at three-turbine operation. Two cobble bar sites were established in Zone 2 and one site in both Zones 4 and 5. There were no suitably vegetated cobble bars in Zone 3.

Site selection within the Denison and Franklin Rivers was largely dictated by logistical constraints. Only those sites accessible by helicopter under a range of flows (except very high flows) were selected for quadrat sites. This resulted in all bank monitoring sites being adjacent to, or accessible from, cobble bars.

The location of all riparian vegetation monitoring sites is shown in Figure 6.1.

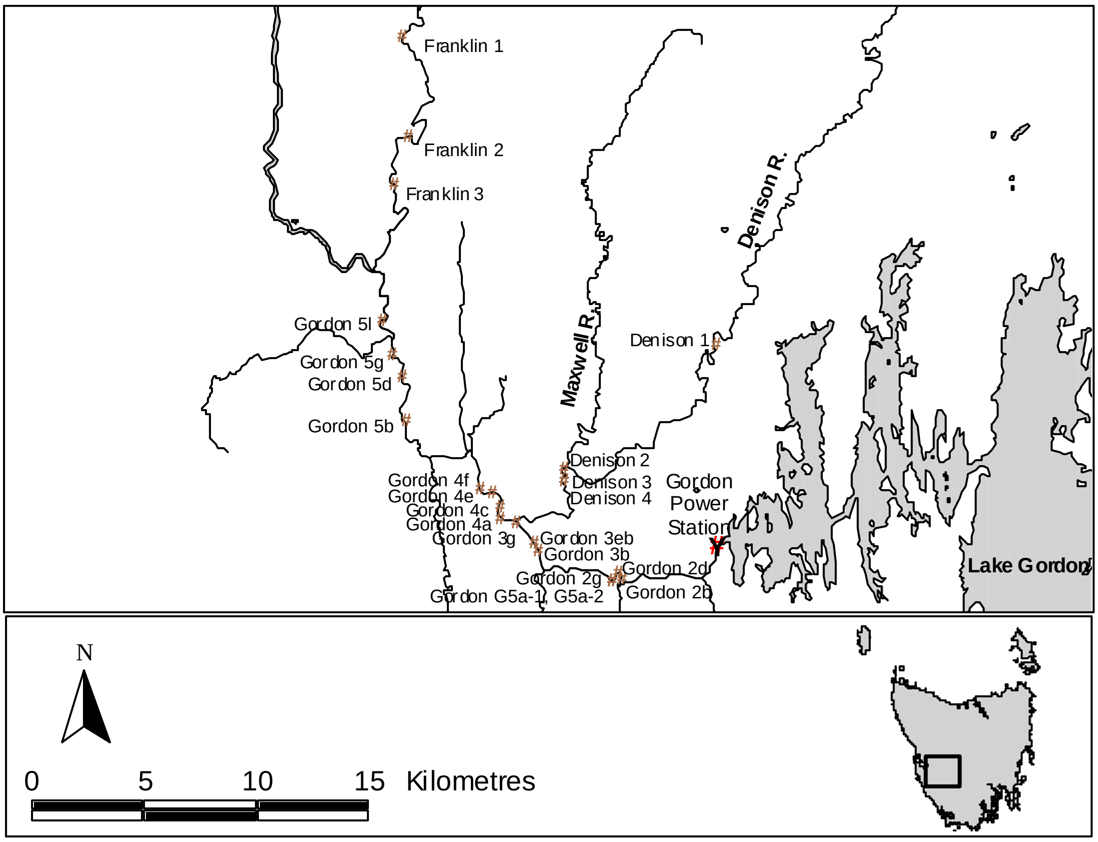


Figure 6.1. Map of the riparian vegetation sites in the Gordon, Denison and Franklin Rivers, monitored during 2001-02.

At each site, one permanent transect, comprising 8 one-metre-square quadrats was established. Quadrats were offset by 0.5 m from the transect line to avoid trampling impacts and were located with reference to the high water mark as shown in Figure 6.2. At most of the quadrat sites the high water mark was delineated by a star picket installed to mark three-turbine operation. At sites where there was no delineation of high water mark, this was estimated by changes in litter cover and ground disturbance.

Sites were permanently marked using deck spikes and flagging tape at the landward end of the transect. Deck spikes were located in the top corners of the most landward quadrats to facilitate accurate future alignment of the quadrats. On areas of uneven ground additional deck spikes were installed. It is anticipated that all quadrat corners will be marked in the future to ensure accurate re-location.

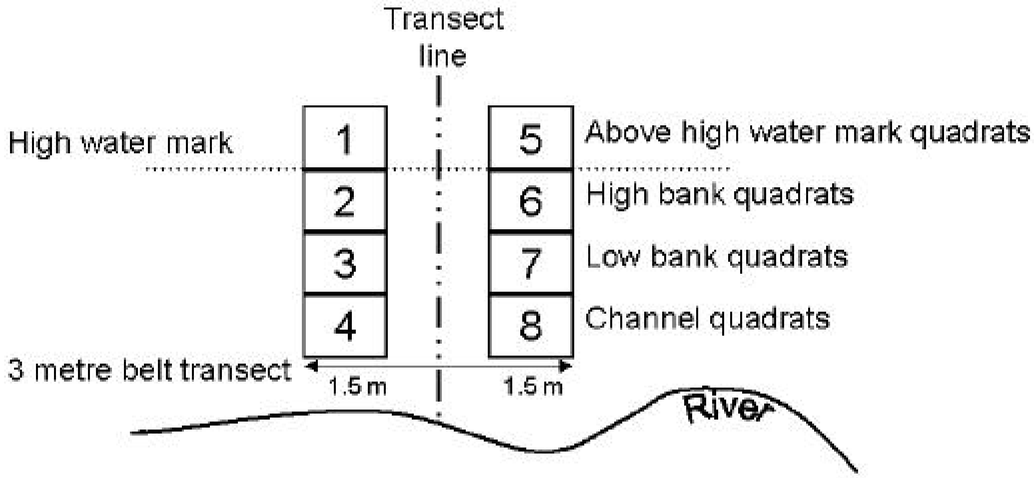


Figure 6.2 Diagrammatic representation of quadrat positions along transects in the Gordon, Franklin and Denison Rivers.

Monitoring within these sites included assessment of ground species cover, levels of recruitment, density of trees and shrubs, health of vegetation and habitat variables including substrate and aspect, as discussed in the following sections.

6.2.1.1 Measures of cover

Percentage overlapping cover values were recorded for ground cover species, and small shrubs (<1m high) only, as this technique is not appropriate for tall species. Measures were visually estimated to the nearest one percent. To minimise the influence of recorder bias field data will be grouped using the Braun-Blanquet cover scale (Kershaw, 1974; Kent and Coker, 1994) and mid points used for analysis (Bonham, 1989). This scale groups the estimates of area occupied by individual plant species, ground litter, bare ground, rock and mosses into the classes defined in Table 6.1, below.

Table 6.1. Rating scale for overlapping cover values of riparian ground cover and small shrub vegetation.

Rating	Area occupied by plant species
+	Very small (<1%)
1	Small 1-5%
2	6-25%
3	26-50%
4	51-75%
5	76-100%

6.2.1.2 Measures of tree and shrub density and stem size

Measures of tree and large shrub density were obtained by stem counts within a belt transect located within the quadrat areas. The number of individuals of tree and shrub species rooted within 1.5m of the central tape line (see Figure 6.2) were recorded. This arrangement formed a 3 m belt transect, 4 metres long. These data were further grouped into size classes representing the width of the stem 30 cm above the base. The size groupings were:

- 1-5 cm
- 6-10 cm
- 11-20 cm
- >21 cm

6.2.1.3 Descriptors of health

The relative health of the vegetation within the quadrat was assessed through visual inspection of indicators of poor health from factors such as inundation and waterlogging. Presence of indicators including chlorosis (yellowing) of older leaves, premature leaf fall, growth of adventitious roots and wilting were noted, particularly for tea-tree. These data have been recorded as presence/absence data for the above indicators.

6.2.1.4 Measures of root exposure

Root exposure was scored as a percent of the quadrat and the average depth of this exposure measured, giving a volumetric measure.

6.2.1.5 Measures of vertical bank change

Measurements of ground conditions and species were taken along each permanent transect running perpendicular to the river. Ground conditions were classified into the following classes:

- FF: Forest with floor litter intact (not regularly inundated);
- MD: Moderately disturbed - some inundation apparent;
- HD: High disturbance - little or no vegetation cover.

6.2.1.6 Measures of recruitment

Recruitment of individual species was assessed within quadrats by counting and measuring seedlings of all species. Some seedlings were not readily identifiable to species and have been recorded as dicotyledons or monocotyledons. These data were recorded as number of seedlings within each quadrat. Where numbers of seedlings for a species were very high (exceeding 10), the measure was recorded as >10 and an average height given.

6.2.1.7 Measures of environmental variables

Environmental variables measured include:

- Aspect – N, NE, E, SE, S, SW, W or NW;
- Illumination – illuminated cobble or shaded bank (as per Davidson and Gibbons, 2001); and
- Substrate type – Alluvial, Alluvial and Cobble or Bedrock, Cobble.

6.2.2 Photo-monitoring sites

Photo-monitoring locations will be established at representative sites covering all substrate types to obtain more general and representative data on patterns and processes. Photo-monitoring has not yet been implemented, and is planned to commence in December 2002. However, a series of photographs was taken in April 2002 to test the methodology.

Photo-monitoring sites will be established at representative sites covering all substrate types within the major reaches to obtain representative data on patterns and processes within the rivers. These photo-monitoring sites will enable accurate, objective measurements of canopies of shrub and tree species, presence/absence of ground layer species and assessment of health indicators. The following factors will be considered in taking oblique photographs to reduce distortion and variation (Magill, 1989):

- Photos will be taken using the same focal length and film type;
- Range poles will be placed on permanent markers at 5 m intervals (parallel to the river);
- Photos will be taken in the same season to avoid seasonal changes.

Post-processing of photos will include scanning into a Geographical Information System package. Photos will be rectified into virtual coordinates using the permanent points and tops of the range poles. A number of transects will be ‘drawn’ across the photograph and the following measurements will be taken and compared over time:

- Canopy width for individual trees and shrubs;
- Number of individual trees and shrubs;
- Numbers of clumps of graminoids and ferns;
- Presence/absence of ground species.

6.3 Results

Riparian vegetation sampling was conducted in Autumn (March-April) 2002 in accordance with the requirements of the Basslink Monitoring Program for the Gordon River. The studies undertaken to date represent the first component of the quantitative studies of riparian vegetation. Quadrat studies were conducted at 23 permanent sites along the Gordon, Franklin and Denison Rivers. Photo-monitoring and recruitment monitoring will commence in December 2002 and be reported in the 2002-03 Gordon River Basslink Monitoring Annual Report.

Surveys were successfully completed at all tributary sites and those in the Gordon River geomorphology Zones 2, 3 and 4. These sites are shown in Figure 6.1.

The data for Zone 5 sites have been excluded as analysis showed very low cover estimates, indicating poor site selection. The location of sites will be reviewed during the next field monitoring to investigate and overcome these assumed sampling and/ or recording errors.

The data presented in this report represent the first monitoring of permanent sites. There are insufficient data for detailed analyses, and these have not been undertaken. The following discussion presents general trends in the riparian vegetation at the high disturbance sites. At the end of the baseline sampling period these data will provide a time series which will be analysed to determine patterns and indicate processes in the riparian vegetation.

A list of the plant species recorded during this monitoring is provided in Table 6.2.

6.3.1 Species diversity and cover

A total of eighty-five species were recorded in the quadrat surveys in all rivers. The species diversity (as number of species) and cover was vertically stratified on the Gordon River banks, concomitant with increasing disturbance.

Figure 6.3, Figure 6.4, and Figure 6.5 show the number of ground species recorded for each quadrat, grouped by quadrat type, for Zones 2, 3 and 4, respectively.

Figure 6.6, Figure 6.7, and Figure 6.8 present the total overlapping cover percentages recorded for each quadrat, grouped by quadrat type, for Zones 2, 3 and 4, respectively.

The lower banks (see Figure 6.2: quadrats 4 & 8, the channel quadrats) recorded sparse vegetation cover with limited species diversity. Ground species were generally limited to bryophytes, occasional ferns (*Blechnum* spp.) and the grasses *Ehrharta* spp. Overhanging shrub and tree species such as *Eucryphia lucida, Richea pandanifolia* and *Nothofagus cunninghamii* were also recorded when branches were under the 1m cut off for cover estimates. The inundation and disturbance tolerant shrub *Leptospermum riparium* was also often present and frequently dominates on lower alluvial banks.

Table 6.2. Composite species list of the riparian vegetation recorded in the fixed monitoring quadrats of the Gordon, Franklin and Denison Rivers.

Life form	Family	Species
Trees	Eucryphiaceae	*Eucryphia lucida*
	Fagaceae	*Nothofagus cunninghamii*
	Mimosaceae	*Acacia dealbata*
		Acacia melanoxylon
		Acacia verticillata
	Monimiaceae	*Atherosperma moschatum*
	Podocarpaceae	*Lagarostrobos franklinii*
	Rhamnaceae	*Pomaderris apetala*
Shrubs	Cunoniaceae	*Anodopetalum biglandulosum*
		Bauera rubiodes
	Elaeocarpaceae	*Aristotelia pedunculata*
	Epacridaceae	*Epacris impressa*
		Richea pandanifolia
		Trochocarpa cunninghamii
	Ericaceae	*Gaultheria hispidia*
	Escalloniaceae	*Anopterus glandulosus*
	Fabaceae	*Pultenaea juniperina*
	Lamiaceae	*Prostanthera lasianthos*
	Mimosaceae	*Acacia mucronata*
	Myrtaceae	*Leptospermum riparium*
	Oleaceae	*Notelaea ligustrina*
	Pittosporaceae	*Pittosporum bicolour*
	Proteaceae	*Cenarrhenes nitida*
		Lomatia polymorpha
	Rubiaceae	*Coprosma quadrifida*
	Rutaceae	*Acradenia frankliniae*
		Nematolepis squamea
		Zieria aborescens
	Thymelaeaceae	*Pimelea drupaceae*
		Pimelea linifolia
	Winteraceae	*Tasmannia lanceolata*

Life form	Family	Species
Herbs and Twiners	Apiaceae	*Hydrocotyle hirta*
		Hydrocotyle muscosa
		Oreomyrrhis gunnii
	Asteraceae	*Brachyscome sp.*
		Gnaphalium spp.
		Lagenifera stipitata
	Haloragaceae	*Gonocarpus teucroides*
	Iridaceae	*Libertia pulchella*
	Liliaceae	*Drymophila cyanocarpa*
	Onagraceae	*Epilobium sp.*
	Oxalidaceae	*Oxalis perrenans*
	Plantaginaceae	*Plantago paradoxa*
	Ranunculaceae	*Clematis aristata*
	Rosaceae	*Acaena novae-zelandiae*
	Rubiaceae	*Galium australe*
	Violaceae	*Viola hederacea*
Grasses, reeds and tussocks	Cyperaceae	*Carex appressa*
		Carex sp.
		Gahnia grandis
		Isolepis crassiuscula
		Isolepis fluitans
		Schoenus maschalinus
		Uncinia sp.
	Juncaceae	*Juncus pallidus*
		Juncus pauciflorus
		Juncus sp.
	Poaceae	*Agrostis sp.*
		Deyeuxia monticola
		Ehrarta tasmanica
		Ehrarta stipoides
		Ehrharta spp.
		Poaceae sp. aff. Danthonia
		Poa sp.
	Restionaceae	*Restio tetraphyllus*

Vegetation type	Family	Species
Ferns	Adiantaceae	*Adiantum aethiopicum*
	Aspleniaceae	*Asplenium flabellifolium*
	Blechnaceae	*Blechnum fluviatile*
		Blechnum minus
		Blechnum nudum
		Blechnum wattsii
		Doodia cordata
	Culcitaceae	*Calochlaena dubia*
	Gleicheniaceae	*Gleichenia microphylla*
		Sticherus tener
	Grammitidaceae	*Grammitis billardieri*
		Grammitis magellanica
	Hymenophyllaceae	*Hymenophyllum australe*
		Hymenophyllum cupressiformis
		Hymenophyllum flabellatum
		Hymenophyllum peltatum

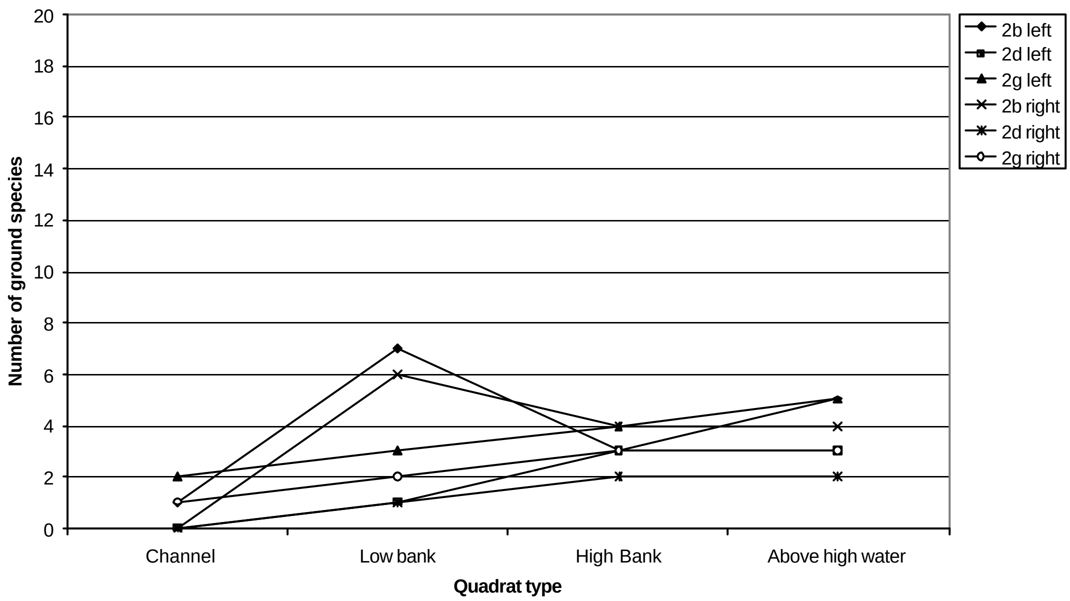


Figure 6.3. Number of ground species by quadrat type for Zone 2 bank sites in the Gordon River in March-April 2002.

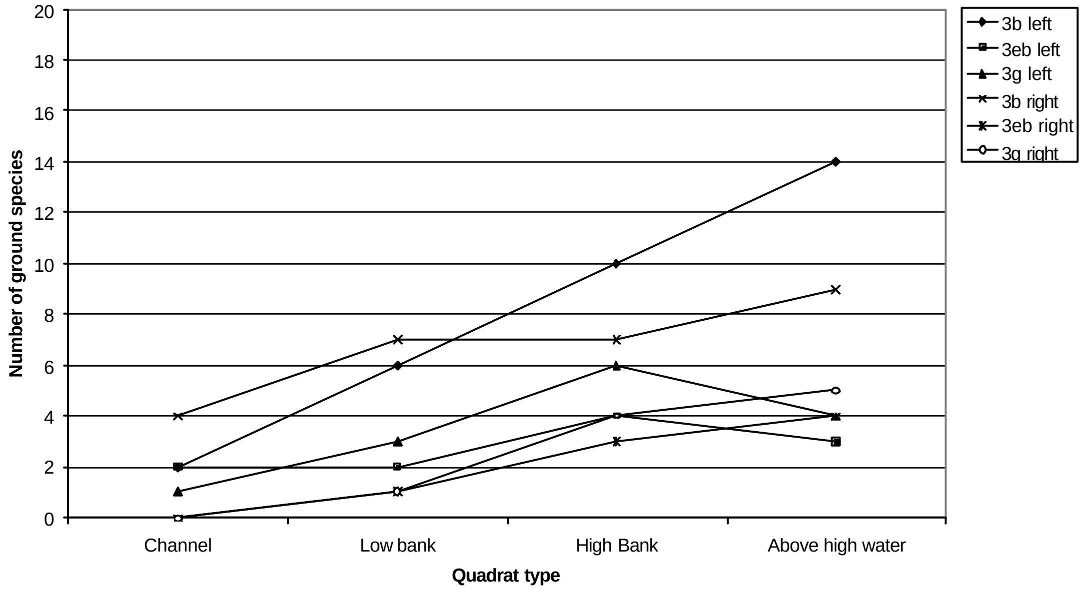


Figure 6.4. Number of ground species by quadrat type for Zone 3 bank sites in the Gordon River in March-April 2002.

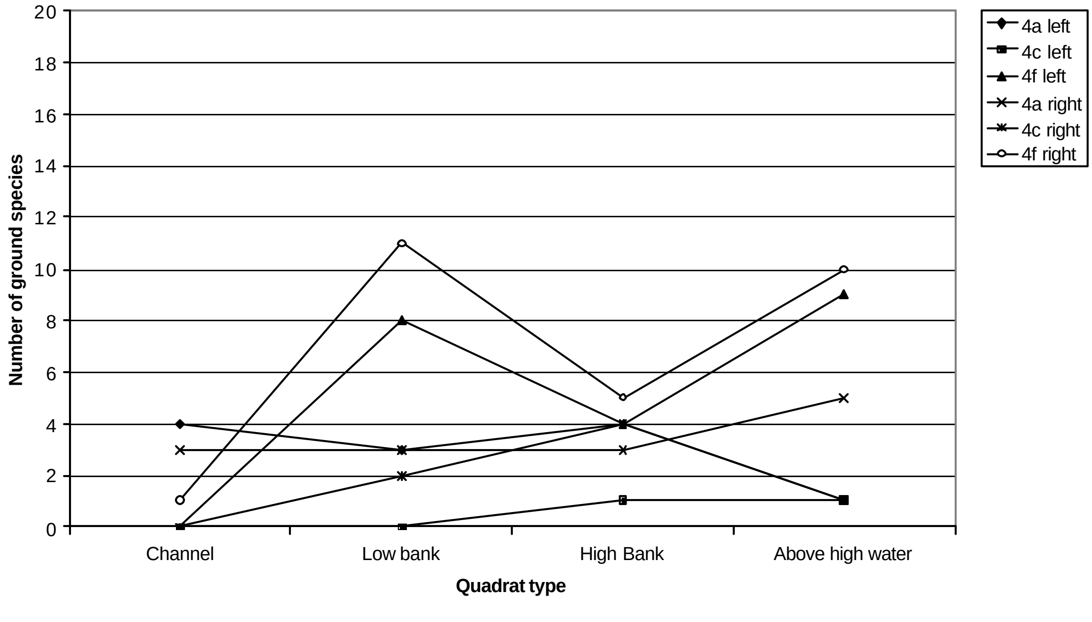


Figure 6.5. Number of ground species by quadrat type for Zone 4 bank sites in the Gordon River in March-April 2002. .

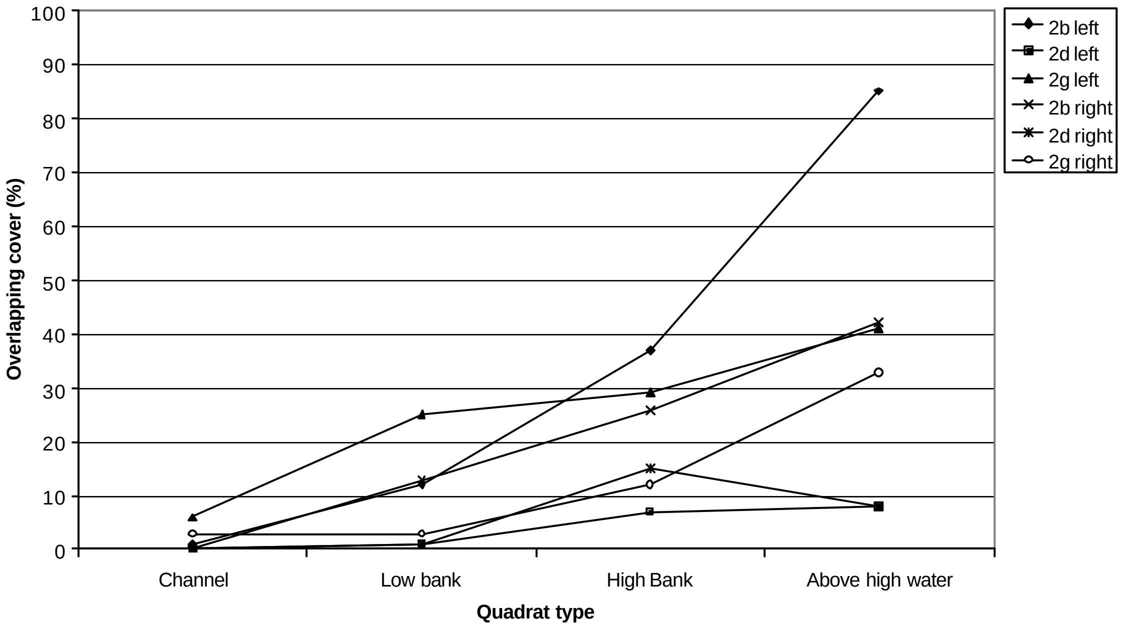


Figure 6.6. Total overlapping cover values for all ground species by quadrat type for Zone 2 bank sites in the Gordon River in March-April 2002.

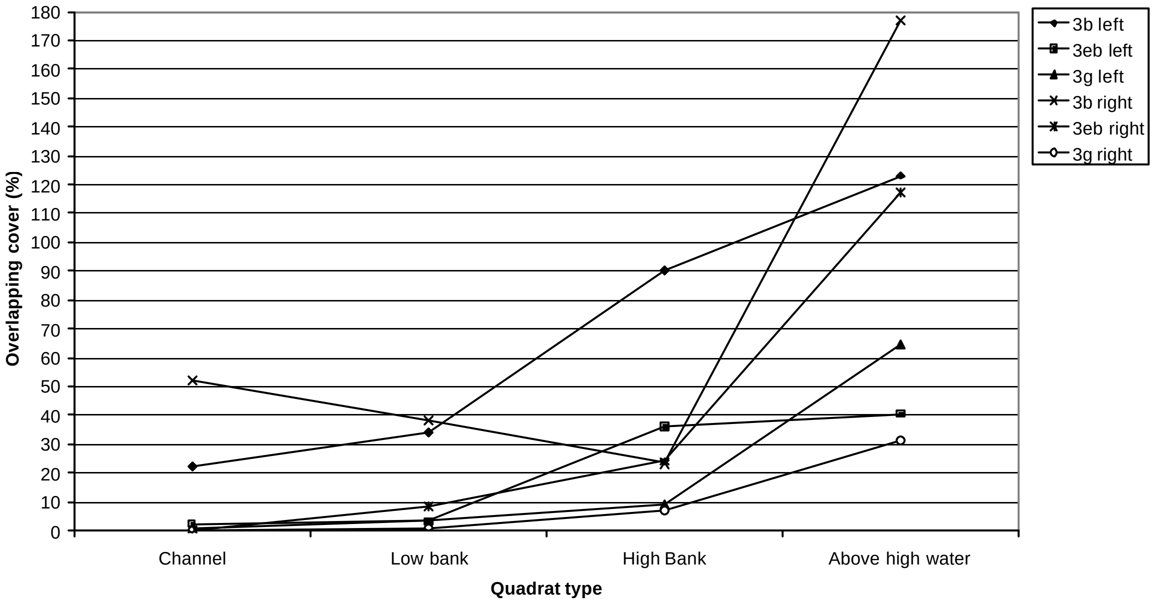


Figure 6.7. Total overlapping cover values for all ground species by quadrat type for Zone 3 bank sites in the Gordon River in March-April 2002.

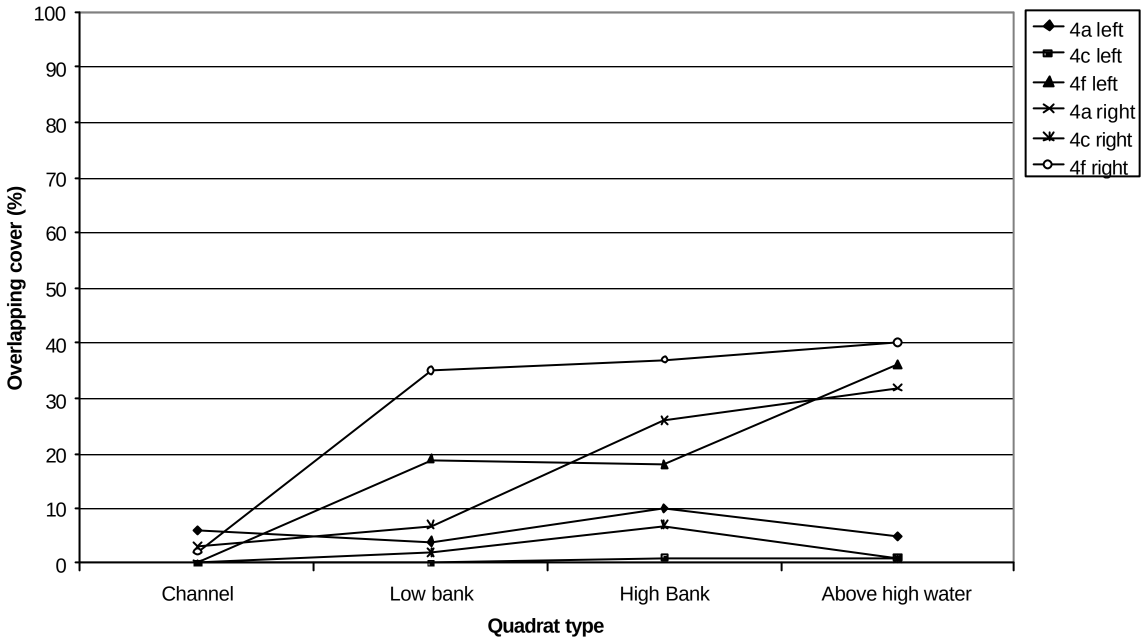


Figure 6.8. Total overlapping cover values for all ground species by quadrat type for Zone 4 bank sites in the Gordon River in March-April 2002.

In the 'low-bank' and 'high-bank' quadrats (see Figure 6.2: quadrats 3 & 7 and 2 & 6, respectively - those associated with 2-3 turbine inundation) the species diversity increased. A greater number of additional fern and graminoid species (*Gleichenia microphylla*, *Isolepis* spp. and *Juncus* spp.) occurred and some isolated shrubs, such as *Coprosma quadrifida*, were rooted within these quadrats. Cover contributed by mosses reduces in relative importance but remains significant.

The 'above high water' quadrats (see Figure 6.2: quadrats 1 & 5) were generally characterised by increased ground species diversity. Shrubs such as *Richea pandanifolia, Trochocarpa cunninghamii* and *Anopterus glandulosus* became more frequent, providing a previously absent middle canopy structure to the vegetation. The ground layer retained a diverse cover of ferns and mosses in many places with overlapping cover also increasing. Some quadrats had substantial overlapping ground layers, largely comprised of ferns and moss cover. Therefore the total overlapping cover at times exceeded one hundred percent (see the 'above high water' quadrats at site 3b –Figure 6.7).

6.3.2 Ground conditions

Mineral substrates predominated in the channel and lower bank quadrat sites at all sites measured, displaying an expected inverse relationship to vegetation cover. Figure 6.9, Figure 6.10, and Figure 6.11 illustrate the percentage of bare ground recorded for the various sites in Zones 2 – 4, respectively.

Site 4c (Figure 6.11) displayed consistently high bare ground and low species cover in all quadrats due to this site being an exposed, near vertical cobble bank.

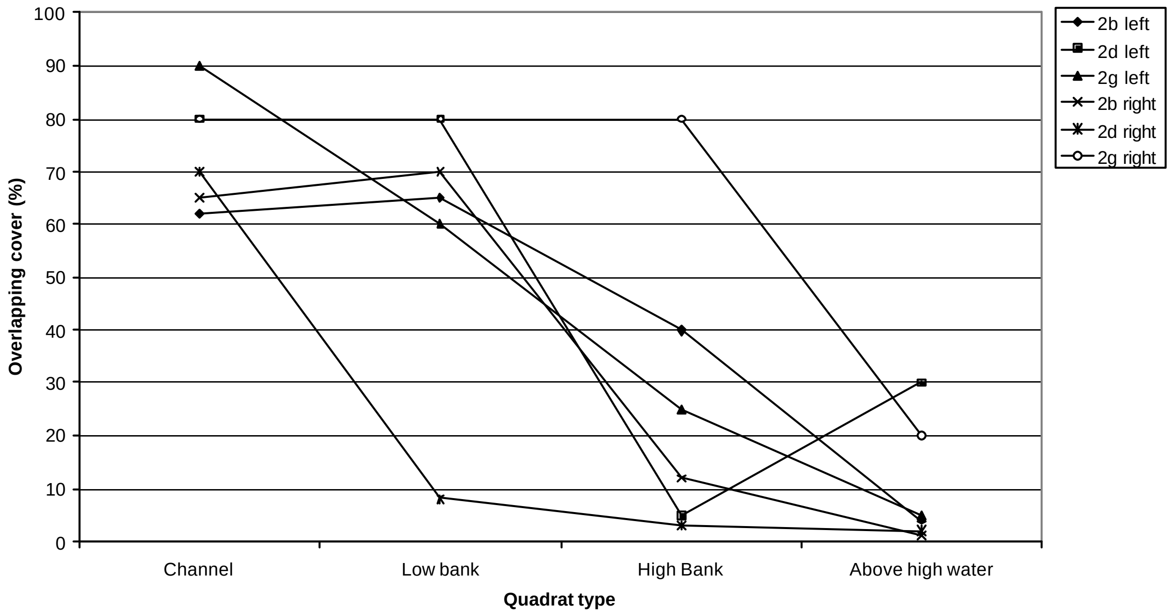


Figure 6.9. Percentage overlapping cover for bare ground by quadrat type for Zone 2 bank sites in the Gordon River in March-April 2002.

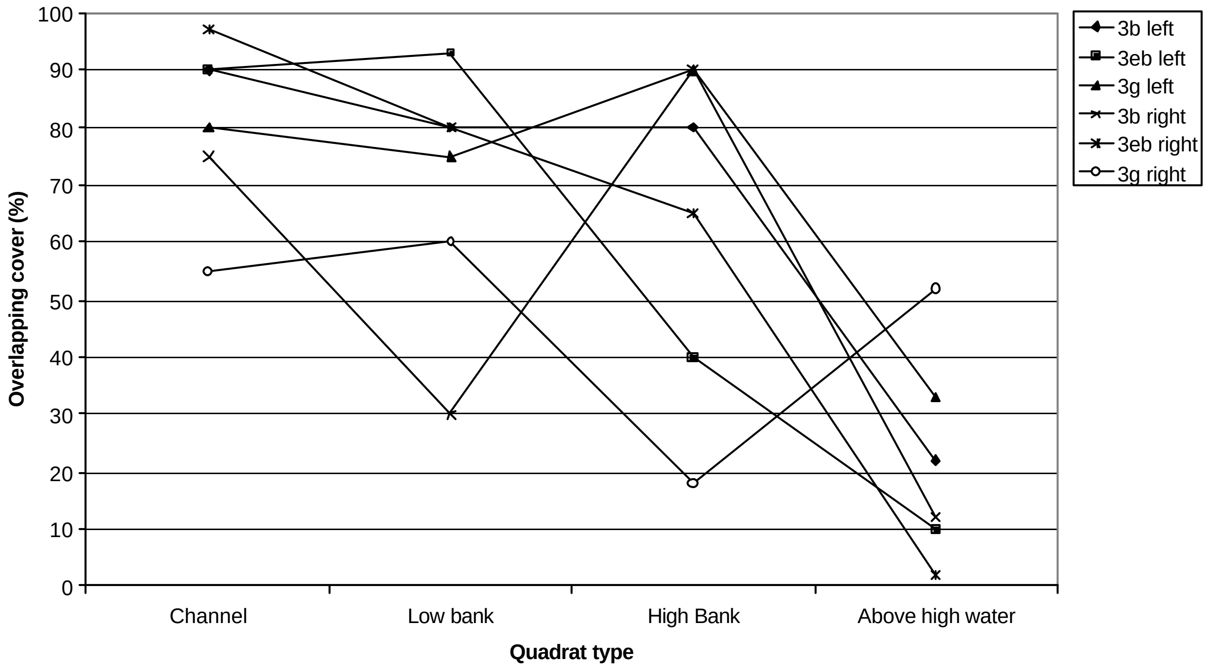


Figure 6.10. Percentage overlapping cover for bare ground by quadrat type for Zone 3 bank sites in the Gordon River in March-April 2002.

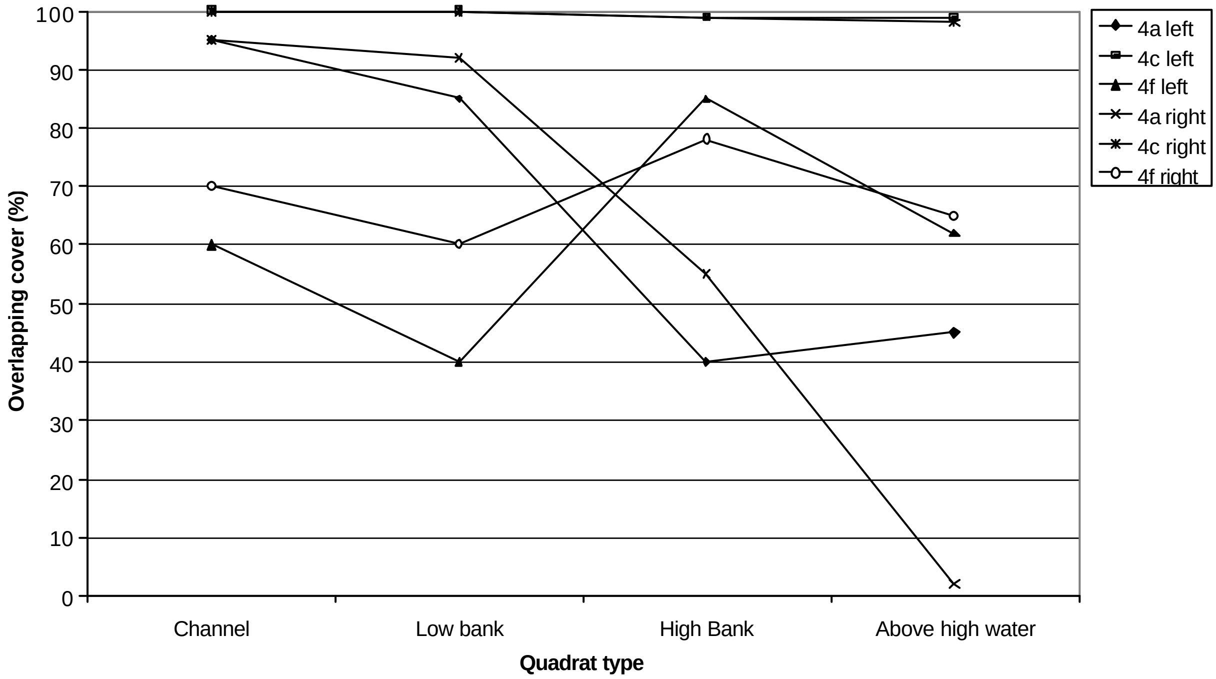


Figure 6.11. Percentage overlapping cover for bare ground by quadrat type for Zone 4 bank sites in the Gordon River in March-April 2002.

Root exposure was consistently higher in the lower quadrats, representing up to 65% cover in the ‘channel’ and ‘low bank’ quadrats. The ‘high bank’ quadrats also recorded high values in areas of localised scour, representing up to 45% cover. As expected, the areas above high water mark had more moderate root exposure: up to 16% at a site in Zone 2. The depth of root exposure followed a similar pattern.

Litter cover was inversely proportional to the amount of disturbance and generally only present in the ‘channel’ and ‘low bank’ quadrats as fixed litter in the form of logs and branches. In the upper quadrats, leaves and smaller branches persisted in more protected sites. Litter cover was subject to influence by the immediate pre-monitoring power station operations and is expected to be highly variable over time.

6.3.3 Species recruitment

Active recruitment was recorded at most sites within each of the geomorphic zones although this was generally restricted to the higher quadrats. Figure 6.12 shows the total number of seedlings measured for each quadrat position in each Gordon River zone.

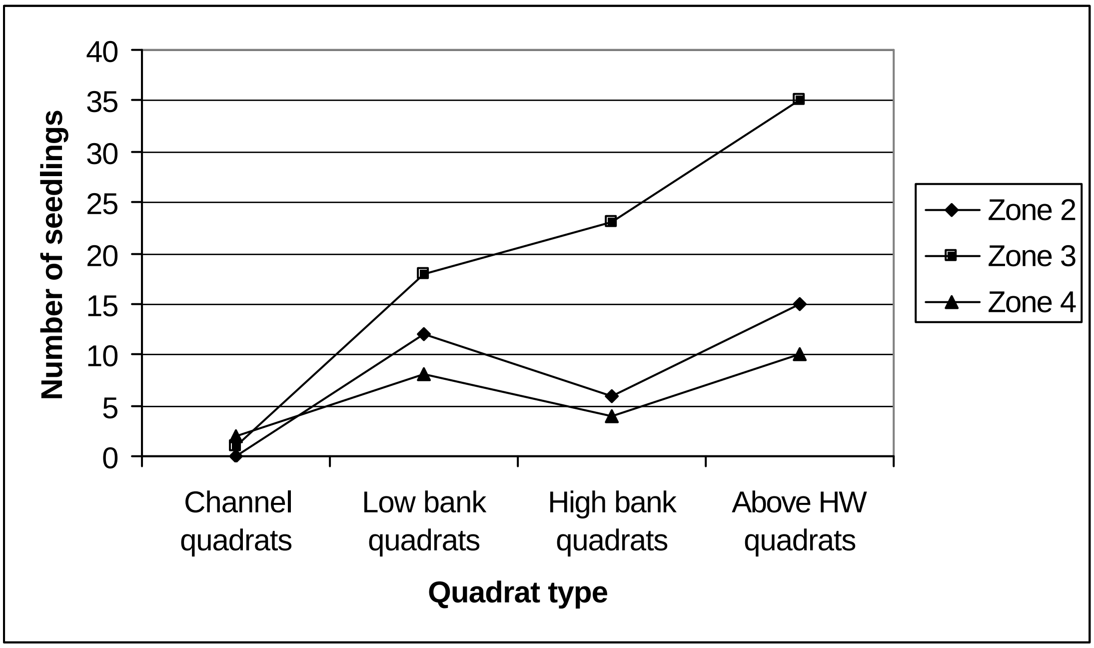


Figure 6.12. Total number of seedlings of all species measured in each quadrat type for each of the Gordon River zones.

Small (<5 cm) even-aged *Clematis aristata* and *Nothofagus cunninghamii* seedlings were locally abundant at many sites. However there were few, if any, older individuals located in the quadrats. Other species present as seedlings included: *Atherosperma moschatum, Coprosma quadrifida, Leptospermum riparium, Pomaderris apetala* and *Acacia verticillata.* In some instances seedlings were not readily identifiable and have been recorded as either monocotyledons or dicotyledons.

6.3.4 Photo-monitoring methodology trial

The photo-monitoring trial indicated that a large number of sites could be covered in the limited field time available. This would enable a larger, representative sample of riparian vegetation on all substrates to be monitored for health indices and changes in diversity and cover.

Initial analysis of photographs indicated that quantitative variables could be determined from the photographs with an appropriate degree of accuracy. Problems of site relocation and angle of photographs can be minimised by installing permanent marking points and using ranging poles to frame the photographs. Species recognition can be difficult in some photographs and can be assisted by lists taken in the field.

Qualitative measurements such as indications of chlorosis may not be as reliable due to light changes and supplementary data will be collected in the field to overcome this.

6.4 Discussion

The results presented above are from a single monitoring event: therefore, meaningful analysis is limited by the short time period and a consequent lack of data.

Patterns of species cover and diversity within the Gordon River were consistent with Davidson and Gibbons (2001) who found significant differences in sites of varying bank height on the Gordon River. The results showed a large degree of variability within each site as a consequence of the extent of the area affected by flows. Species diversity, species overlapping cover and litter cover were all directly proportional to bank height (quadrat location) whilst bare ground and root exposure were inversely proportional.

Recruitment within the Gordon River has not been previously quantified but had been regarded as generally low (Davidson and Gibbons, 2001). The diversity and level of recruitment identified in this monitoring was higher than expected at most sites and not confined to the quadrats above high water mark. This suggests that recruitment of some species was not restricted by viable propagule availability and that conditions suitable for germination do occur. However, the absence of older cohorts casts doubt on the longevity and establishment of seedlings, and more temporal data points are required to confirm any patterns. The presence of large numbers of *Nothofagus cunninghamii* seedlings may also indicate a localised masting event which is common for this and numerous other rainforest species (Read 2001). Recruitment monitoring will be undertaken twice yearly to help elucidate any trends.

Sampling was completed successfully for Zones 2, 3 and 4. Zone 5 data were excluded from discussion due to assumed sampling and recording errors and will be reviewed in the next field session. Field data sheets have been redesigned to minimise the likelihood of such errors occurring in the future. Site relocation will be undertaken for those sites deemed unsuitable. Zone 5 is the zone of least impact from flow regulation, receiving flood and natural flows from both the Denison and Franklin Rivers.

7 Macroinvertebrates

7.1 Introduction and Methods

Macroinvertebrate sampling was conducted in spring (October) 2001 and autumn (March) 2002. Both quantitative (surber) and rapid bioassessment (RBA) sampling was conducted at nine 'monitoring' sites in the Gordon River between the power station and the Franklin River junction. Monitoring was also conducted at six 'reference' sites in rivers within the Gordon catchment but in undisturbed condition.

7.1.1 Monitoring Sites

The locations of the monitoring sites are shown in Figure 7.1.

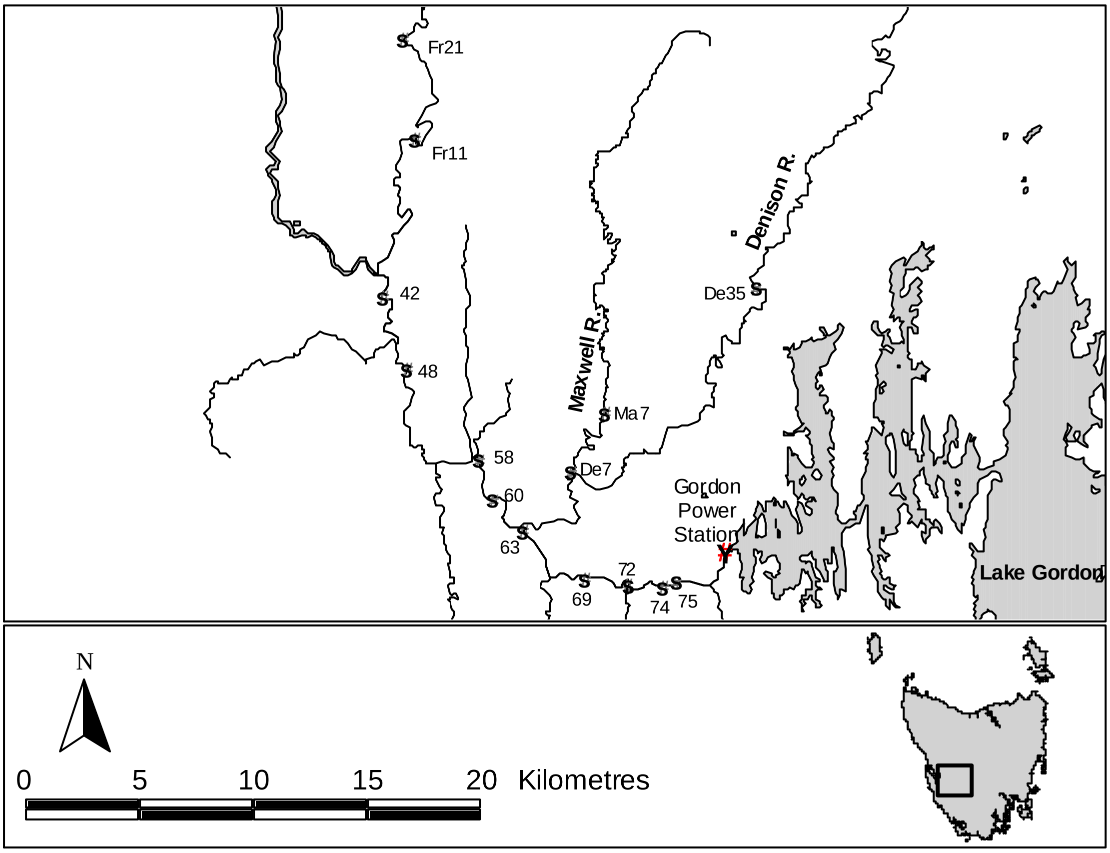


Figure 7.1. Map of the locations of macroinvertebrate monitoring sites in the Gordon, Denison and Franklin Rivers for 2001-02.

7.1.2 Macroinvertebrate sampling

The same monitoring method was conducted at all sites. Thus, at each site at low flows, riffle habitat was selected and sampled by:

- Collecting 10 surber samples (30 x 30 cm area, 500 micron mesh) by hand disturbance of substrate to a depth of 10 cm and washing into the net; and
- Disturbing substrate by foot and hand immediately upstream of a standard 250 micron kick net over a distance of 10m.

All surber samples from a site were pooled and preserved (10% formalin) prior to lab processing. Samples were elutriated with a saturated calcium chloride solution and then sub-sampled to 20% using a Marchant box subsampler, and random cell selection. The subsamples were then hand picked and all fauna identified to family level with the exception of oligochaetes, Turbellaria, Hydrozoa, Hirudinea, Hydracarina, Copepoda and Tardigrada. Chironomids were identified to sub-family.

All RBA samples were live-picked on site for 30 minutes, with pickers attempting to maximise the number of taxa recovered. All taxa were identified to the same taxonomic levels as described above.

7.1.3 Habitat variables

A set of standard habitat variables were recorded at each site, and a number of variables were recorded from maps.

7.1.4 Analysis

No detailed analysis has been conducted for this report, other than to derive O/E scores and plot summary trends. All RBA data were analysed using the Hydro RIVPACS models developed by Davies *et al*. (1999), with predictions and O/Epa and O/Erk values derived using the RBA macroinvertebrate data in combination with key ‘predictor’ habitat variables.

7.2 Results

7.2.1 Quantitative (surber) sampling

Data from surber samples are shown in Table 7.1 and Table 7.2, below. A trend of increasing diversity and total abundance was apparent in these data (see Figure 7.2), generally consistent with that observed by Davies and Cook (2001) in 1998-99. A high value for site 60 (G9) was due to a very high density of simuliids observed in spring 2001 – values for all other taxa at this site were consistent with the overall downstream trend. Mean values for reference sites are also shown in Figure 7.2.

Table 7.1. Quantitative macroinvertebrate data (abundances as n per 0.18 m^2) for Gordon and reference sites sampled in Spring 2001.

		Date:	Spring (October 2001)														
		River:	Gordon											Denison	Maxwell	Jane	
		Type:	Monitoring									Reference					
		Site:	**75**	**74**	**72**	**69**	**63**	**60**	**57**	**48**	**42**	**Fr11**	**Fr21**	**De7**	**De35**	**Ma7**	**Ja7**
Order	**Class**	**Family**															
Cnidaria	Hydrozoa										1						
Platyhelminthes	Turbellaria				1			2		2	2					2	
Nematoda				1	1			2	2	4	5				1	6	8
Mollusca	Bivalvia	Sphaeriidae							1							4	
	Gastropoda	Hydrobiidae			1	4	4	1	8	2	8	3				221	1
		Planorbidae															
		Lymnaeidae															
		Ancylidae															
		Unid. gastropods															
Annelida	Hirudinea																
	Oligochaeta		1	19	6	1	26	29	13	54	85	24	99	57	58	109	224
Arachnida	Hydracarina			1				1	1		1	1	2		1	7	1
Crustacea	Amphipoda	Paramelitidae								4	2					6	
		Ceinidae						1									
	Isopoda	Phreatoicidea														5	
		Janiridae	9	4	1		2			2	7					1	
	Ostracoda															1	
Insecta	Collembola														2	1	
	Plecoptera	Eustheniidae			1	1	1	1		1	1	2	1		8	3	
		Gripopterygidae		2	3	3	16	7		10	3	16	8	4	11	37	9
	Ephemeroptera	Leptophlebiidae			3	2	3	20	16	9	20	23	32	56	97	91	110
		Baetidae							1			32	15	4	28	42	37
Diptera	Chironomidae	Chironominae		1		3	4		2	21	49	43	9	1	19	10	5
		Orthocladiinae			1		14	5	2	1	5	16	1		21	8	3
		Podonominae		2	2	1	8	5	4	15	7	19	4		6	5	6
		Tanypodinae					1									1	
		Diamesinae	1	2								2					
		Aphroteniinae										1			5	3	3
		Simuliidae		39	7	10	42	1076	17	537	331	436	230	44	124	39	48
		Tipulidae					1			1							1
		Athericidae															
		Blephariceridae		2			4	17		22	22	2	14		2	1	
		Ceratopogonidae							1			4	4	2			6
		Empididae					8								2	3	
		Unid. pupae					3			8	5	22	8		4	2	4
	Trichoptera	Calocidae														2	
		Conoesucidae		1	1		15	12		5	13	5	1	2		15	
		Ecnomidae															
		Glossosomatidae					1				1					11	
		Helicophidae															
		Helicopsychidae															
		Hydrobiosidae		1	1		3	8	1	3	8	11	9	4	5	9	5
		Hydropsychidae					65	272	14	4	19			2	1	7	1
		Hydroptilidae			1		2								3	1	
		Leptoceridae				1				1		1	8			2	15
		Philopotamidae									1					3	
		Philorheithridae							2				1			2	2
		Polycentropodidae													1		
		Unid. pupae															
	Coleoptera	Adult Elmidae					5	6	5		2	9	3	19	23	44	24
		Larval Elmidae					4	6	24	3	7	10	12	139	176	137	263
		Larval Scirtidae						1	1			8	1		8	2	3
		Larval Psephenidae												2		9	2
		N Taxa	**3**	**12**	**14**	**9**	**22**	**19**	**18**	**21**	**24**	**22**	**20**	**13**	**23**	**37**	**23**
		Total Abundance	**11**	**75**	**30**	**26**	**232**	**1472**	**115**	**709**	**605**	**690**	**462**	**336**	**606**	**852**	**781**

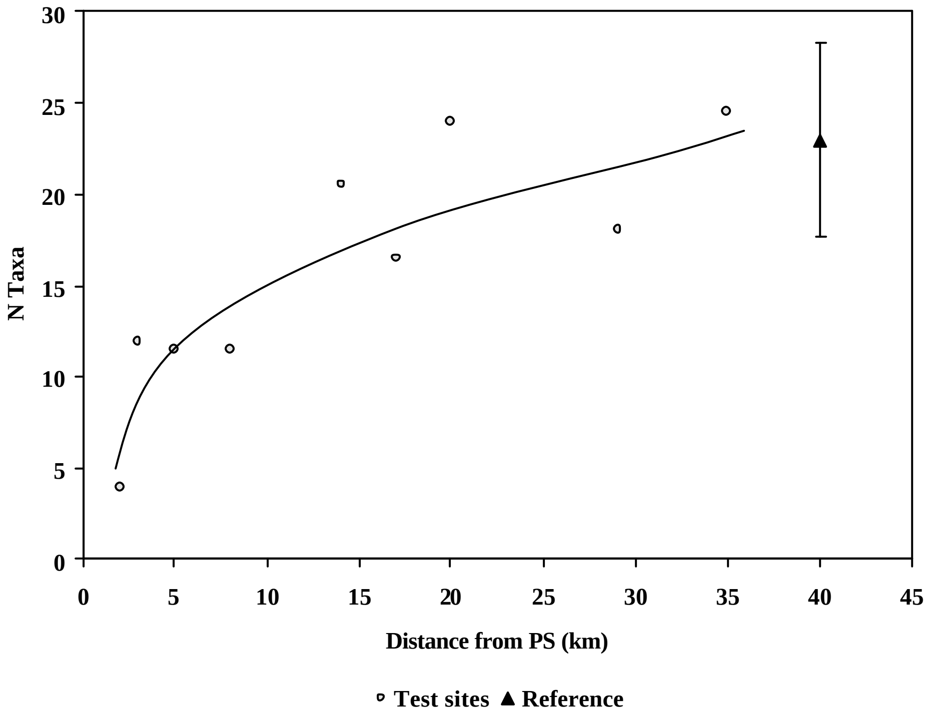
In general, all sites upstream of the Denison River fall below reference site abundance and diversity, while sites down stream of the Denison have similar numbers of taxa to reference sites but are lower in abundance. Again, this is consistent with the Davies and Cook (2001) observations from 1998-99.

Table 7.2. Quantitative macroinvertebrate data (abundances as n per 0.18 m^2) for Gordon and reference sites sampled in Autumn 2002.

		Date:	Autumn (March 2002)														
		River:							Gordon						Denison	Maxwell	Jane
		Type:					Monitoring							Reference			
		Site:	75	74	72	69	63	60	57	48	42	Fr11	Fr21	De7	De35	Ma7	Ja7
Order	**Class**	**Family**															
Cnidaria	Hydrozoa					2											
Platyhelminthes	Turbellaria								2		1	1	1				
Nematoda					1	6			7		4	3			2		
Mollusca	Bivalvia	Sphaeriidae				2											
	Gastropoda	Hydrobiidae	1		1	2	1	1	12	1	6	1		3	1	25	
		Planorbidae															
		Lymnaeidae															
		Ancylidae							1			4	8			1	
		Unid. gastropods															
Annelida	Hirudinea																
	Oligochaeta			7	10	6	30	10	73	8	141	111	9	9	16	4	68
Arachnida	Hydracarina								4		2	1		3	2	5	2
Crustacea	Amphipoda	Paramelitidae			1		2		15		3						
		Ceinidae															
	Isopoda	Phreatoicidea		2				2									
		Janiridae	21	5		1	1	2	9	1	4	4					
	Ostracoda																
Insecta	Collembola																
	Plecoptera	Eustheniidae				1											
		Gripopterygidae		6		7	11		4	1	4	2	1	4	6	4	3
	Ephemeroptera	Leptophlebiidae	2	2	5	9	13	7	7	9	16	66	26	54	53	85	125
		Baetidae		2						3		7	9	4	31	42	39
Diptera	Chironomidae	Chironominae		2		7			2		45	5	1	1	4	4	2
		Orthocladiinae	3	4	8	2	2	2	31	1	10	11	2	3	27	15	3
		Podonominae					2		2		3	3	2	3	11	2	6
		Tanypodinae															
		Diamesinae	1														
		Aphroteniinae							1						2		
		Simuliidae		4	3	9	49	31	80	36	57	64	172	117	62	14	97
		Tipulidae		2					1			1			2		
		Athericidae							1								
		Blephariceridae		1			3	2	1	3	1	14	12		2		8
		Ceratopogonidae										4			1	1	
		Empididae					5		1		2			1	14	1	
		Unid. pupae			1				2	1	3	3	2			1	
	Trichoptera	Calocidae															
		Conoesucidae					3		2	1	1	5			4	10	1
		Ecnomidae											1			14	
		Glossosomatidae					6		1	6	1	4		4	2	1	8
		Helicophidae									2						
		Helicopsychidae												1			
		Hydrobiosidae				1	5	2	2	2	6	7	3	6	8	5	5
		Hydropsychidae			1		88	3	100	1	50	1	1		2	4	
		Hydroptilidae					1							1		2	
		Leptoceridae										3		1	16	8	1
		Philopotamidae							1		1						
		Philorheithridae										5		2	24	8	27
		Polycentropodidae														1	
		Unid. pupae					2	3	3		4						
	Coleoptera	Adult Elmidae				2	1	3	24		6	7	5	10	42	40	16
		Larval Elmidae		3				6	26	7	66	2	71	86	85	211	179
		Larval Scirtidae						4	1			91	25	33	22	35	52
		Larval Psephenidae					2		1					2	4	5	1
		N Taxa	**5**	**12**	**9**	**14**	**19**	**14**	**30**	**15**	**25**	**27**	**18**	**21**	**26**	**27**	**19**
		Total Abundance	**28**	**40**	**31**	**57**	**227**	**78**	**417**	**81**	**439**	**430**	**351**	**348**	**445**	**548**	**643**

7.2.2 RBA (kick) sampling

Data from of RBA kick-sampling and live picking are shown in Table 7.3 and Table 7.4, below. These data were entered, along with values of predictor variables into the combined season RIVPACS models developed by Davies *et al*. (1999). O/E values derived from the presence/absence (pa) and rank abundance (rk) models are shown in Table 7.5. The trends in O/E values with distance downstream of the power station are shown in Figure 7.3, accompanied by values for reference sites sampled at the same time.



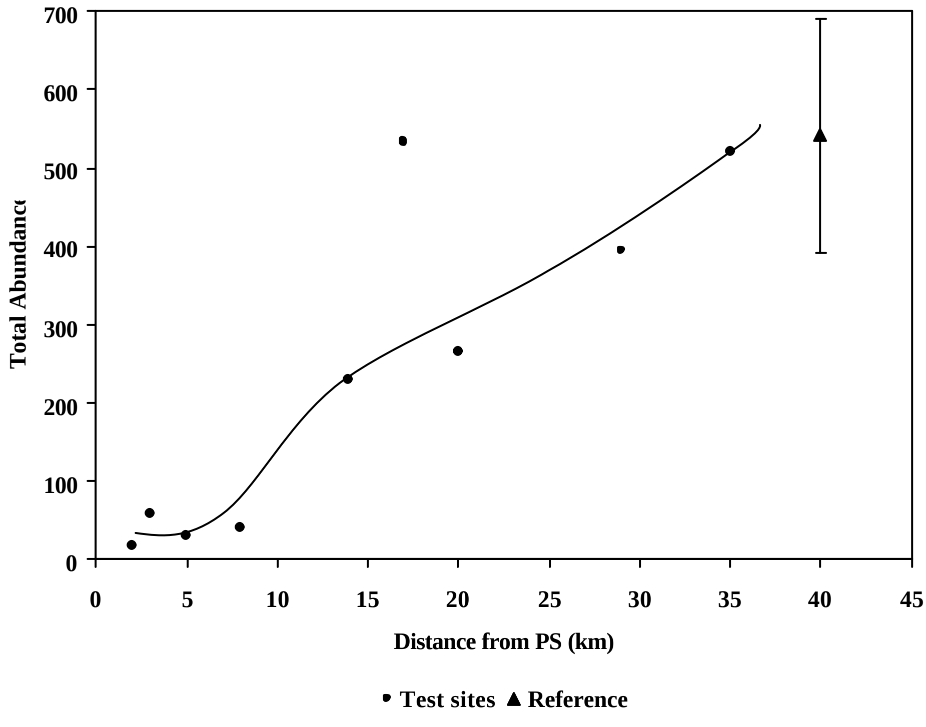


Figure 7.2. Trends in diversity (number of taxa) and total abundances of macroinvertebrates in the Gordon River with distance downstream of the Gordon Power Station. Mean values for the reference sites sampled at the same time are also shown, with error bars (+/- 1 SD).

Overall, the values of O/E and the downstream trends are similar to those observed previously in 1995-96 and 1998-99 by Davies *et al.* (1999) and Davies and Cook (2001). Thus, O/E values are low in the river reach upstream of the Denison River junction.

Table 7.3. RBA macroinvertebrate data (abundances per live picked sample) for Gordon and reference sites sampled in spring 2001.

		Date:	Spring (October 2001)														
		River:	Gordon												Denison	Maxwell	Jane
		Type:	Monitoring												Reference		
		Site:	75	74	72	69	63	60	57	48	42	Fr11	Fr21	De7	De35	Ma7	Ja7
Order	**Class**	**Family**															
Platyhelminthes	Turbellaria		1	1			4										
Nematoda							1				3					5	
Mollusca	Bivalvia	Sphaeriidae															
	Gastropoda	Hydrobiidae				1			2								
Annelida	Hirudinea																
	Oligochaeta			16	32	6	23	35	21	42	36	33	8	25	16	8	24
Arachnida	Hydracarina											1	1			3	1
Crustacea	Amphipoda	Paramelitidae	17		2	1			10	9	5		1				
	Isopoda	Phreatoicidea															
		Janiridae	3				1	1				1					
	Plecoptera	Eustheniidae	4	2	1	5	2		2		3		5	6	5	2	2
		Austroperlidae			1	1			1								
		Gripopterygidae	2		8	7	18		4	3	6	6	12	8	3	30	9
		Notonemouridae	3		2	1					2	1					
	Ephemeroptera	Leptophlebiidae	11	3	33	10	7	50	24	30	49	69	103	84	66	79	112
		Baetidae										21	9	5	12	33	9
	Odonata	Telephlebiidae							1								
Diptera	Chironomidae	Chironominae		1		2	2		1	1	3	1	3		1	4	1
		Orthocladiinae	2	8		1	6		2		1	1	9		2	6	1
		Podonominae			2	2	36	27	15	29	9	25	10	11	9	19	5
		Tanypodinae															
		Diamesinae	6														
		Aphroteniinae															
		Simuliidae		38	4	6	18	107	35	36	26	60	82	41	18	9	6
		Tipulidae	1		2	2	1		1	1	1	1			2	2	1
		Athericidae			1								1		1		
		Blephariceridae		4			3	1		4	4	7	4				2
		Ceratopogonidae										3	4		2		
		Empididae		1	1			2								2	
		Unid. pupae			1		3			1	2						
	Trichoptera	Calocidae										2					
		Conoesucidae		1			3	3		2	1		1			3	
		Glossosomatidae														4	6
		Hydrobiosidae	11	3	7	4	19	26	7	15	6	17	21	25	29	26	14
		Hydropsychidae					40	27	23	4	1					17	1
		Hydroptilidae															
		Leptoceridae					1					2	1	1		1	2
		Philopotamidae															
		Philorheithridae			1				2					1	1	1	2
		Unid. pupae					2			2						5	
	Coleoptera	Adult Elmidae	1					3	3	3		9	10	11	17	31	28
		Adult Hydrophilidae												1			
		Larval Elmidae					1	3		1		5				1	5
		Larval Scirtidae	1	1		1					1	2	6		2		
		Larval Psephenidae			2							1		1	3	2	1
Nematomorpha		Gordiidae								1				1			
		N Taxa	13	12	16	15	20	12	17	17	18	21	19	14	17	23	20
		Total Abundance	63	79	100	50	191	285	154	184	159	268	291	221	189	293	232

Table 7.4. RBA macroinvertebrate data (abundances per live picked sample) for Gordon and reference sites sampled in autumn 2002.

		Date:	Autumn (March 2002)														
		River:	Gordon												Denison	Maxwell	Jane
		Type:	Monitoring												Reference		
		Site:	75	74	72	69	63	60	57	48	42	Fr11	Fr21	De7	De35	Ma7	Ja7
Order	**Class**	**Family**															
Platyhelminthes	Turbellaria		1				2										
Nematoda									1	1							
Mollusca	Bivalvia	Sphaeriidae						1									
	Gastropoda	Hydrobiidae					1						1			5	
Annelida	Hirudinea					1											
	Oligochaeta		4	5	4	4	9	19	11	13	18	16	11	13	4	4	23
Arachnida	Hydracarina											3	4	2	2	9	1
Crustacea	Amphipoda	Paramelitidae	5	2	3	1	7	2	12	9	1					4	
	Isopoda	Phreatoicidea					2	1	1								
		Janiridae	30	1	2		1					1		1			
	Plecoptera	Eustheniidae			1	2	3	2	1	5	5	2	3	17	9	2	2
		Austroperlidae															
		Gripopterygidae	3	57	21	25	17	7	19	18	3	4	6	28	17	8	11
		Notonemouridae	4														
	Ephemeroptera	Leptophlebiidae	8	2	24	43	18	14	15	55	35	73	70	44	42	46	73
		Baetidae					1		2	4	6	19	24	3	15	38	18
	Odonata	Telephlebiidae													1		
Diptera	Chironomidae	Chironominae				2				1	1	2	1	1	2		
		Orthocladiinae	2	1		1			1			1	2	1	2		2
		Podonominae			1	1		4	1	2	10	2	5	10	7	2	6
		Tanypodinae															
		Diamesinae	1	1													
		Aphroteniinae					2										
		Simuliidae		19	2	17	18	19	16	39	30	19	31	26	21	3	18
		Tipulidae						1					3	5	7	3	1
		Athericidae						1						1		1	
		Blephariceridae		3				1		1	6			3			
		Ceratopogonidae															
		Empididae					1						1				
		Unid. pupae															
	Trichoptera	Calocidae						2									3
		Conoesucidae		2			2				5	2	3			13	2
		Glossosomatidae										1			1		8
		Hydrobiosidae	12	19	27	9	20	9	31	31	20		41	45	45	29	64
		Hydropsychidae					13	9	4	2	6	2	1	2	3	6	
		Hydroptilidae													1		
		Leptoceridae								1		3	1	3	3	6	1
		Philopotamidae						1									
		Philorheithridae				1	2	1			1	3	4	5	5	15	
		Unid. pupae						11		5					10	7	6
	Coleoptera	Adult Elmidae	1	6			1	3	11	2	5	12	8	16	19	27	23
		Adult Hydrophilidae															
		Larval Elmidae			1			1				4	7	3	2	3	3
		Larval Scirtidae			3	1		1	1			16	18	14	1	7	5
		Larval Psephenidae					2					2	1	3	4	5	2
Nematomorpha		Gordiidae															
		N Taxa	11	12	11	13	19	21	15	16	15	20	22	22	23	22	20
		Total Abundance	71	118	89	108	122	110	127	189	152	187	246	246	223	243	272

7.3 Conclusion

Overall patterns of diversity, community composition and abundance are similar to those observed previously in 1995-96 and 1998-99 by Davies *et al.* (1999) and Davies and Cook (2001). There is no evidence of any substantial changes since those surveys.

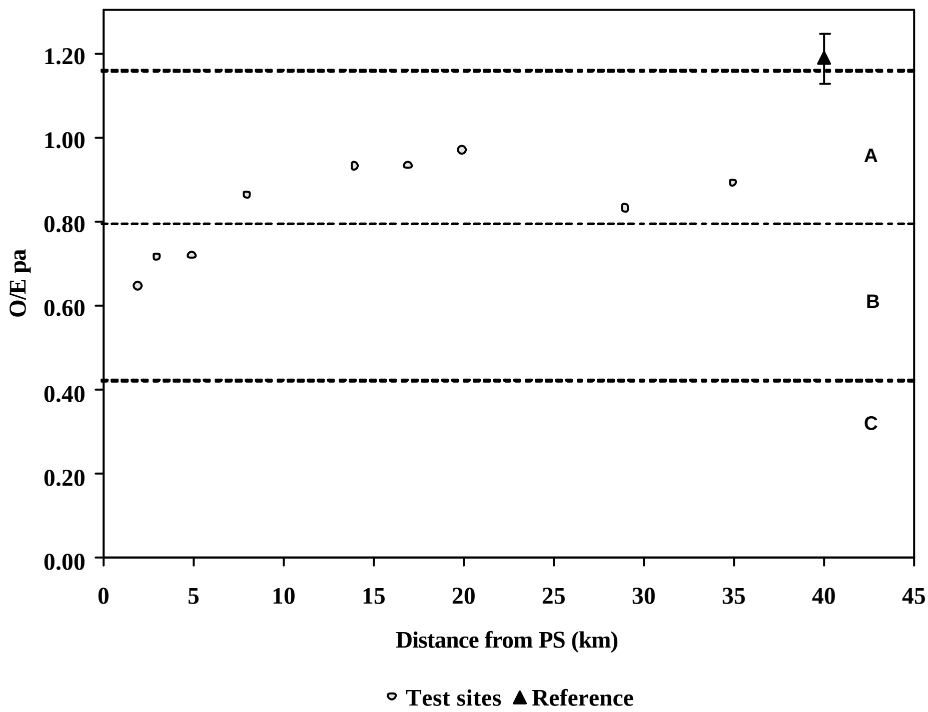
O/E values follow the same trend as observed by Davies and Cook (2001). Some further evaluation may be required of interannual variation in O/E values, since reference site values generally fell at the upper range or above the previously established bounds for the reference condition (see Figure

7.3). However, paired t-tests of O/Epa and O/Erk values for all sites did not suggest a significant change between this survey and that conducted in 1998-99 (both with $p > 0.05$). This indicates that no consistent significant change in O/E values had occurred across all sites between these dates. Care should however be taken in future surveys to evaluate if there is a need to change band bounds with variation in reference site O/E values between years.

The Gordon River Basslink Monitoring Program requires that the data from the quantitative macroinvertebrate samples be analysed to assess changes in time in relation to reference sites by conducting analysis of variance with time (year) and location (Gordon section vs reference rivers) as factors, with abundance of each species and overall diversity as test statistics, and with a time*location interaction term being used to assess the significance of any changes. The intent of these requirements is to assess changes in macroinvertebrate communities associated with the effect of changed flow regimes under Basslink. Such detailed analysis of these data will be conducted at the end of the pre-Basslink phase of this program, when more data have been acquired.

Table 7.5. O/E values derived from combined season 2001-2002 RBA macroinvertebrate data for Gordon and reference sites. O/Epa, O/Erk = derived using presence/absence and rand abundance data, respectively.

Site	River	OEpa	OErk
Monitoring			
75	Gordon	0.64	0.51
74	Gordon	0.71	0.54
72	Gordon	0.72	0.70
69	Gordon	0.86	0.70
63	Gordon	0.93	0.95
60	Gordon	0.93	0.95
58	Gordon	0.97	0.95
48	Gordon	0.83	0.90
42	Gordon	0.89	0.92
Reference			
Fr11	Franklin	1.15	1.06
Fr21	Franklin	1.23	1.11
De7	Denison	1.22	1.16
De35	Denison	1.22	1.16
Ma7	Maxwell	1.22	1.17
Ja7	Jane	1.08	1.03



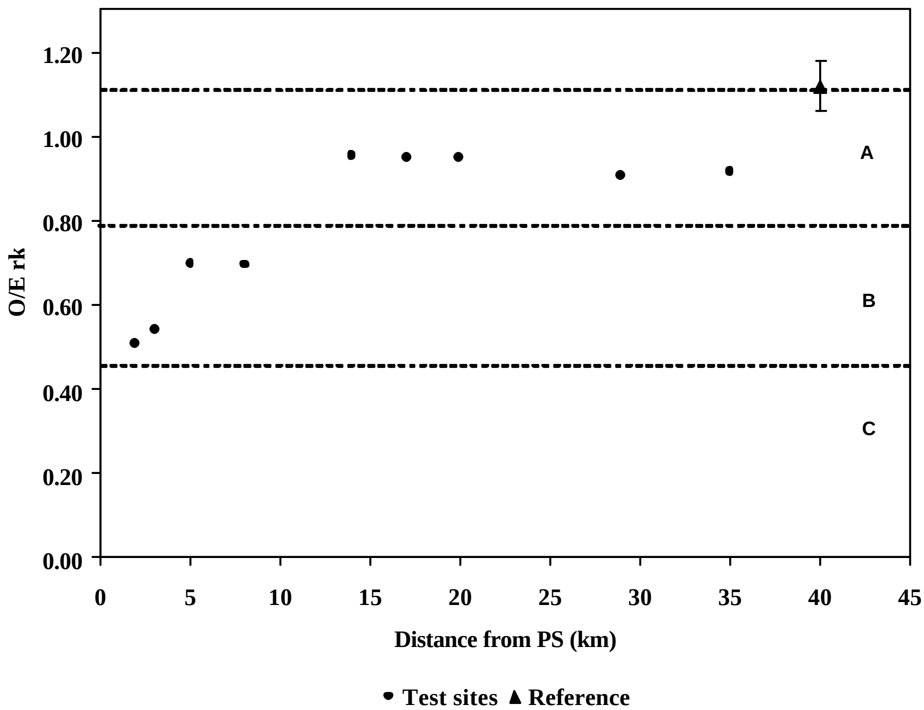


Figure 7.3. Trends in O/Epa and O/Erk values for macroinvertebrates in the Gordon River with distance downstream of the Gordon Power Station. Mean values for the reference sites sampled at the same time are also shown, with error bars (+/- 1 SD). Horizontal lines indicate bounds of impairment bands A, B and C (see Davies and Cook 2001).

8 Algae

8.1 Introduction and Methods

Benthic algae were surveyed in spring (October) 2001 and autumn (March) 2002. This monitoring constitutes the first year of the pre-Basslink algal monitoring being conducted in the Gordon River catchment.

Quantitative (quadrat-based) assessment of algal cover was conducted at nine 'monitoring' sites in the Gordon River between the power station and the Franklin River junction.

8.1.1 Sample sites

Survey sites were the same as for the Basslink monitoring macroinvertebrate sampling being conducted in the Gordon River, as shown in Figure 8.1.

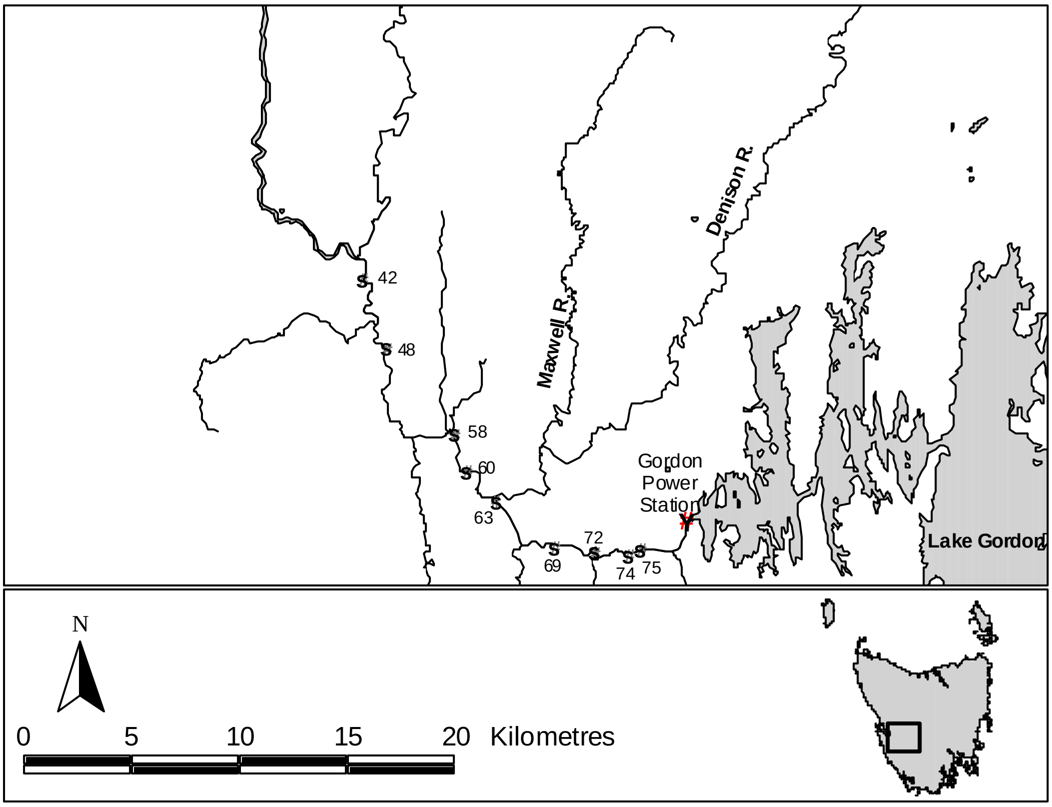


Figure 8.1. Map of the algal monitoring sites in the Gordon River for 2001-02.

8.1.2 Benthic algal survey

All algal assessment was conducted by measuring percent area of cover at fixed distances along existing transects across the Gordon River, with one transect assessed at each site.

As required under the monitoring program specifications, the distance from the transect datum ('head peg') and percent cover was initially recorded at 0.5 m intervals across the relevant sections for three transects. This was deemed too subjective ('relevant sections' being undefined).

Algal density was generally consistent, though patchy, within areas of similar substrate. Preliminary analysis of these density data indicated that cover assessment at nine locations (using a 3 x 3 sample layout – see below) appeared adequate for describing mean algal cover within areas of similar substrate, while also providing 'point' estimates for assessing trends through time. All subsequent data collected in spring 2001 was therefore conducted as follows:

- Transects were re-established by running a measuring tape across the river from the existing transect head-peg (which was designated as the zero distance offset);
- The transect, perpendicular to the direction of river flow, was then divided into broadly similar 'zones', characterised by consistency of benthic substrate composition;
- Three sites were located at ¼, ½ and ¾ of the distance across each zone;
- Algal density, as % cover, was recorded using a 30 cm x 30 cm quadrat at three locations – 1m upstream of the transect line, on the transect line, and 1 m downstream of the transect line – this typically resulted in between 18 and 72 cover assessments per transect;
- Within each quadrat, density was reported for four broad floristic groups – filamentous algae, characeous algae, moss and macrophytes.

Zones were defined following visual inspection of the channel substrate, and defined in terms of their dominant substrate composition, e.g.: cobble/gravel, sand/silt, sand/snags, bedrock etc.

Subsequent analysis revealed that the use of the 3 x 3 location sampling layout was not adequate. There were significant departures from mean zone percent cover under this design compared with more intense sampling; e.g. at 0.5 m and 2.5 m transect offset intervals, as shown in Figure 8.2.

A final sampling design was adopted in which algal cover was measured every 2.5 m across the channel, independent of zones, but with the extent of substrate zones still being recorded.

Five scrapes of filamentous algae/moss were taken from the upper surface of boulder/cobbles in the centre of each zone at each site on all sampling occasions. The five scrapes were pooled, resulting in a single, composite and representative sample of the dominant benthic species present within each zone. These samples were preserved in 10% formalin for later identification.

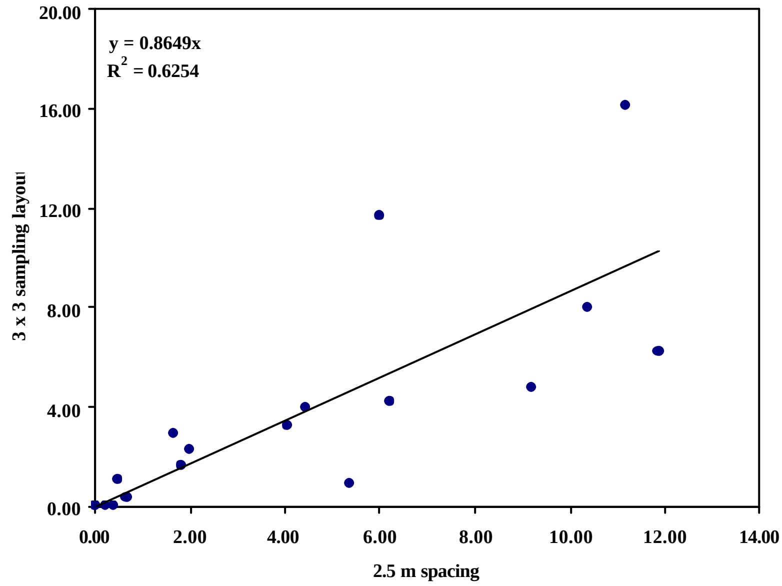


Figure 8.2. Plot of estimate of % mean algal and moss cover derived from the 3 site x 3 location sampling design vs that derived from sampling very 2.5 m across the channel, for all sites. Note the high scatter of points and relatively low r^2.

8.1.3 Analysis

The 2001-02 algal monitoring provided only the first year's data on benthic algae. Consequently, no detailed analyses were conducted for this report, other than to summarise plant cover scores and plot summary trends. Detailed analyses will be completed following the end of first three years of monitoring, when sufficient data are available.

Peak algal and moss cover positions are also reported below.

8.2 Results

Monitoring was successfully completed across the entire river channel for sites 75, 74, 72, 69, 63 and 60. The presence of deep, fast water prevented survey across the entire channel for sites 57, 48 and 42. An average 68m of river bed was surveyed across all sites, ranging from 43 to 91 m.

Data from the monitoring are summarised in Table 8.1. Aquatic flora have a consistently low to moderate cover across all sites, with a grand mean of 10.5% cover by area over both seasons. Moss and filamentous algae were the dominant forms, and had similar, low overall mean percent cover across all sites (4-5% of benthic area). Mean moss cover was highly variable, ranging from 0.2 to 19%. Mean site percent moss and filamentous algal cover were positively correlated ($p < 0.005$, Spearman's rho = 0.673), as shown in Figure 8.3.

A trend of decreasing algae and moss cover with distance from the Gordon Power Station is evident (see Table 8.1), with some increase in the reaches upstream of the Franklin River junction (sites 48 and 42). Low values were observed in both seasons at site 72, which may be related to the significant increase in sand substrate evident downstream of the Albert River.

Table 8.1. Summary cover data for algae, moss and macrophytes surveyed in spring 2001 and autumn 2002 for Gordon River sites. * indicates transects for which only part of the channel could be surveyed. Total distances surveyed from the transect head pegs are indicated.

			Mean % cover				Width
Site	Date	N Zones	Moss	Filamentous green	Characeous	Macrophytes	surveyed
75	Oct-01	4	18.70	13.00			67
74	Oct-01	6	4.70	21.70	7.80		61
72	Oct-01	7	0.21	1.03	4.68	0.40	79
69	Oct-01	4	15.97	5.57		0.02	75
63	Oct-01	8	0.83	4.15			69
60	Oct-01	5	0.24	0.58			86
57	Oct-01	3*	1.08				53
48	Oct-01	3*	1.06				54
42	Oct-01	2*	0.45	1.87			43
75	Mar-02	5	4.40	8.13			68
74	Mar-02	5	16.55	12.30	4.25		65
72	Mar-02	8	3.00	2.15	2.53	6.82	93
69	Mar-02	7	1.02	1.13			70
63	Mar-02	6	1.27	0.24	0.07		70
60	Mar-02	6	0.41	2.44			85
57	Mar-02	6	0.52	0.01			65
48	Mar-02	4*	4.63	3.44			70
42	Mar-02	4*	5.75	5.57			43

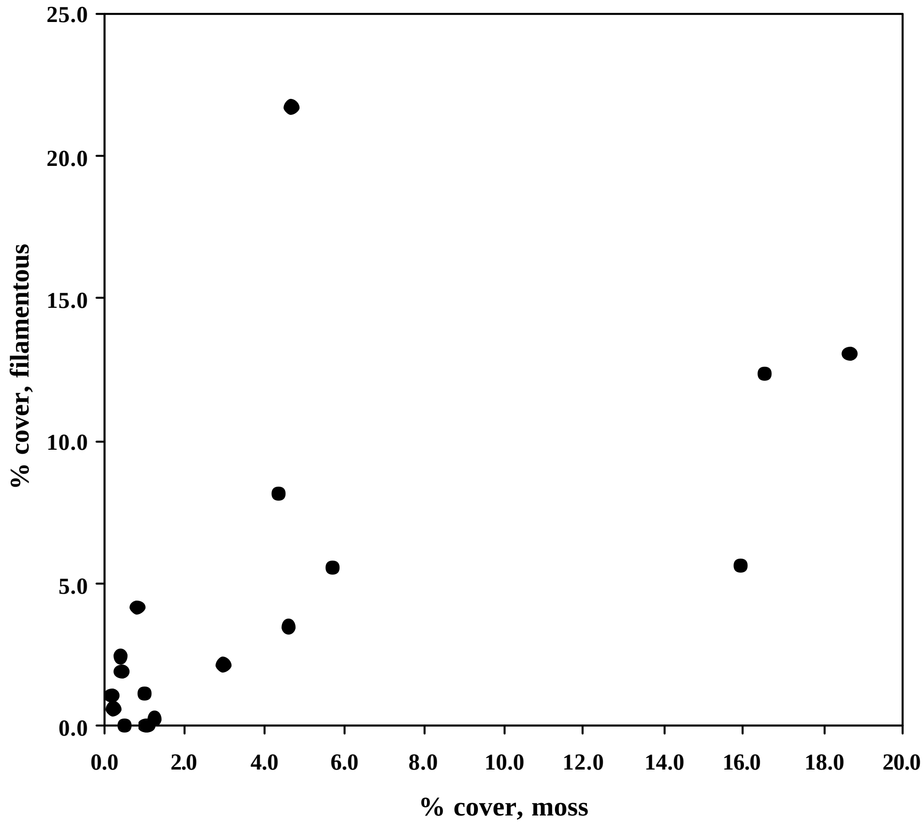


Figure 8.3. Relationship between mean percent filamentous algal and moss cover in the Gordon River in spring 2001 and autumn 2002.

Characeous algae were only observed at sites 74 and 72, with both *Chara* sp. and *Nitella* evident. Macrophytes only occurred at sites 72 and 69. Both *Callitriche* sp. (starworts) and *Isolepis fluitans* were observed at these sites. Densities were low, with the single exception of the silt-mud backchannel at site 72, in which macrophyte cover was occasionally high (up to 90-95%).

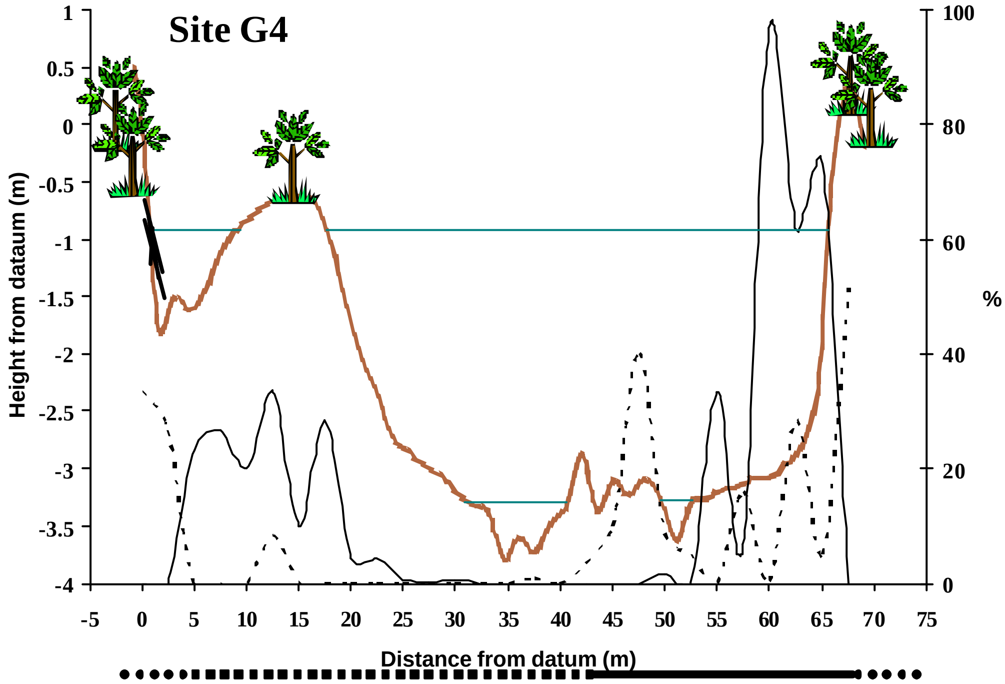
Channel profiles for sites 75 and 63 are shown in Figure 8.4, with percent cover of moss and filamentous algae (for autumn 2002) superimposed. They illustrate the variability across the channel profile, as well as the relative differences between zones (eg bedrock and cobble substrates), and the differences in overall cover between an upstream site, 75, and a downstream site, 63.

8.3 Conclusion

Sampling was conducted successfully, though with some adjustment to sampling layout aimed at reducing field time and data redundancy.

Overall aquatic algal and plant cover was low, and decreased downstream from the Gordon Power Station to the Franklin River junction. The degree to which higher algal and moss cover is related to the presence of the power station is unknown at this stage. Patterns of algal density may also be dictated by the inflow of fine grained, scouring sediments from tributary streams (eg the Albert River), and hence geomorphic differences in channel sediment dynamics.

Several years' data are required in order to confirm the patterns observed during 2001-02. Relationships between the influence of the Gordon Dam and Power Station, river geomorphology and algal cover will then be assessed at the end of the pre-Basslink monitoring period.



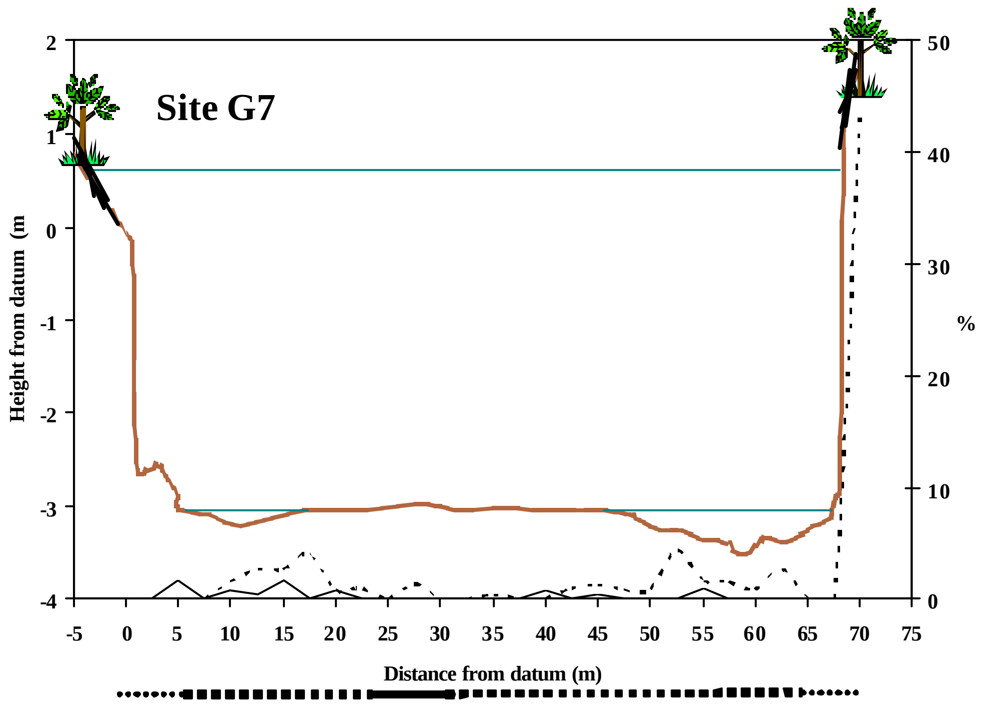


Figure 8.4. Cross sectional profiles of the Gordon River at sites 75 (G4 - Gordon R downstream of Albert Gorge) and 63 (G7 - Gordon R upstream of Denison River), showing distribution of % cover of filamentous algae (as solid black curve) and moss (as dashed black curve). Brown line shows channel bed elevation (relative to transect head-peg datum), and horizontal green lines show water surface elevations when power station is off and at full load. The positions of riparian vegetation and snags are also indicated.

The horizontal line under plot shows positions of substrate zones – bedrock (solid line), cobble-gravel (dashed line), sand (small dotted line), soil-sand (large dotted line).

9 Fish

9.1 Introduction

The specific aims of the Gordon River Fish Monitoring Program are to:

- quantify pre and post-Basslink variability in the relative abundance of fish populations to allow statistical comparison between these times and appropriate reference sites;
- assess changes in the longitudinal fish community structure of the Gordon River with the aim of identifying any changes in the zone of influence;
- detect and assess changes in CPUE which may result from Basslink operations;
- determine the incidence of fish stranding both pre- and post-Basslink; and
- determine any changes to the fish populations of affected tributaries, in particular, if recruitment success for juvenile galaxiids is improved under Basslink.

This report summarises the monitoring results of the two surveys undertaken during 2001-02.

9.2 Methods

Monitoring was conducted in December 2001 and April 2002. Approximately thirty Gordon catchment 'test' sites were monitored on each occasion; 3 river and 3 tributary sites in each of the 5 Gordon catchment zones, and these are listed in Table 9.1. Figure 9.1 shows the Gordon catchment fish monitoring zones. A discussion on zone allocations is contained in Howland *et al.* (2001). Additionally, seven river 'reference' sites and 4 tributary 'reference' sites were monitored in conjunction with the Gordon catchment sites. These sites are shown in Table 9.2.

Nine optional sites, listed in Table 9.3, were included in the monitoring for 2001-02. These sites were monitored if time and logistics permitted. However, core sites took priority in the sampling regime. Optional sites consist of 6 'test' and 3 'reference' tributary and river sites and were included to provide opportunistic supplementary data for the monitoring program.

A number of core sites were not monitored due to bad weather, high flows or equipment failure at the time of sampling. In December 2001, these were:

- Denison u/s Maxwell;
- Denison @ Maxwell; and
- Pocacker River.

In April 2002, these were:

- Denison @ Maxwell;
- Mudback Creek; and
- Site 69 (G6).

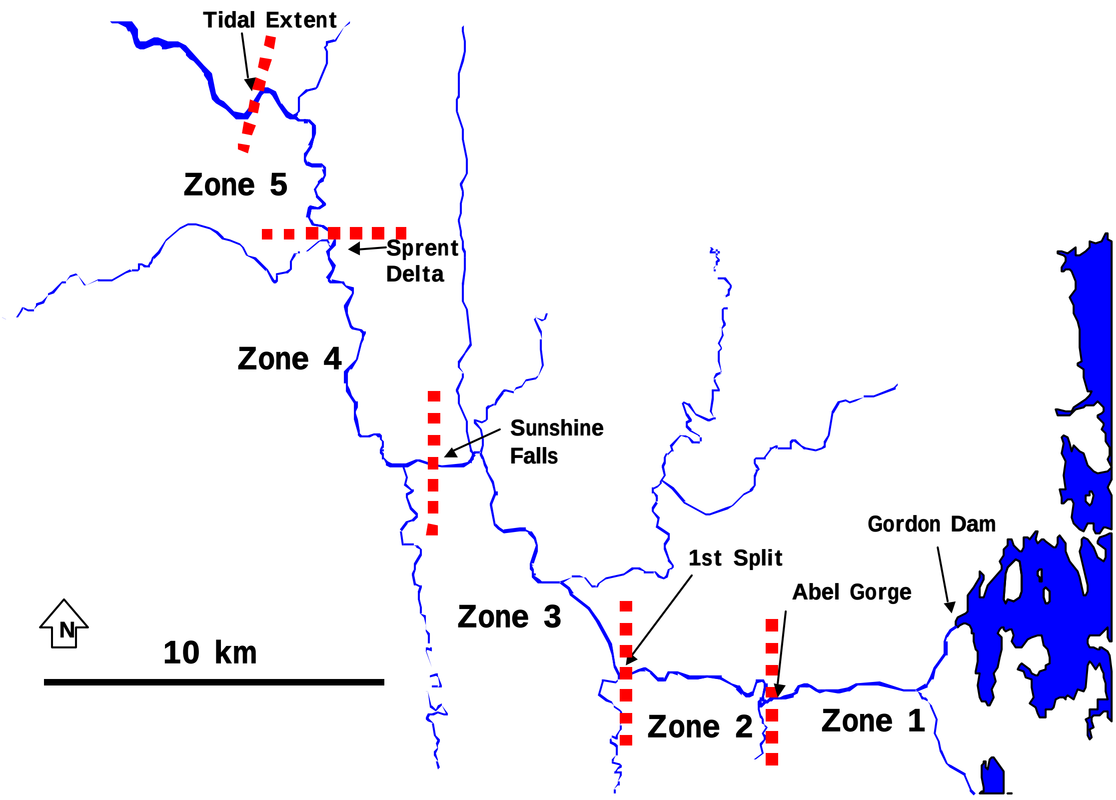


Figure 9.1. Fish monitoring zones in the Gordon River.

Table 9.1. Gordon catchment 'test' fish monitoring sites.

Zone	River Sites	Tributary Sites
1	75, 74, 73	Serpentine River, Indigo Creek, Piguenit Rivulet (1 site each)
2	72, 71, 69	Albert River, Splits Creek and Mudback Creek (1 site each)
3	68, 63, 57	Smith River (1 site), Harrison Creek (1 site) and Denison River (3 sites - u/s Gorge, @ Maxwell, u/s Maxwell)
4	54, 51, 46	Howards Creek, Olga River, Platypus Creek, Sprent River (1 site each)
5	45, 44, 42	Franklin @ Pyramid Island

Table 9.2. 'Reference' fish monitoring sites.

Zone (catchment)	River sites	Tributary sites
8 (Franklin)	Franklin d/s Big Fall, Franklin u/s Big Fall Franklin @ Canoe Bar	Forester Creek, Ari Creek, Wattle Camp Creek
9 (Birches Inlet)	Sorell River	Pocacker River
13-14 (Henty)	Henty u/s Bottle Creek, Henty @ Yolande River Henty @ Sisters	None recommended

Table 9.3. Optional sites surveyed during the 2001-02 fish monitoring program.

Zone	River Sites	Tributary Sites
1	76 (G2)	Left bank Creek @ site 75
2	Gordon @ Grotto Creek	none
3	Site 60 (G9), Gordon @ G8	Orange River
8 (Franklin)	Franklin @ Forester Creek, Franklin @ Wattle Camp Creek	none
14 (Henty)	Henty @ West Sister	none

Fish surveys were undertaken by backpack electrofishing following the methods described in Howland *et al.* (2001). Surveys were typically conducted by 1 to 3 teams, each consisting of two people, with an electrofishing target of greater than 1200 seconds shocking time for each site visit. In some cases this time target was not achievable as fishable habitat was limited by the flow conditions at the time.

9.3 Results and Discussion

A total of 1113 fish, comprising nine species, were captured during December 2001 and April 2002. The species consisted of:

- two exotic species (*Salmo trutta* and *Perca fluviatilis*);
- one species of eel (*Anguilla australis*);
- two species of lamprey (*Mordacia mordax* and *Geotria australis*);
- three galaxiid species (*Galaxias brevipinnis*, *G. maculatus*, *G. truttaceus*); and
- one bovichthyid species, the Sandy or freshwater flathead (*Pseudaphritis urvillii*).

Eight fish species were caught in the 1999 and 2000 surveys (Howland *et al.* 2001). Consequently, it is highly significant that redfin perch (*Perca fluviatilis*) were caught during both the December 2001 and April 2002 monitoring.

As this is the initial year of the monitoring program, insufficient data precluded comprehensive statistical analysis of catch data i.e. interannual, longitudinal and population structure analysis. Although catch records for the majority of species are relatively small, length-frequency histograms have been included to give a general indication of number and size ranges of key species caught.

9.3.1 Exotic Species

9.3.1.1 Brown trout

Brown trout (*Salmo trutta*) have been captured previously at most sites and were dominant in the upper zones of the middle Gordon River. This species can reproduce within the tributaries of the Gordon River and therefore has an advantage over the native species, all of which are diadromous in riverine environments. The native species have to negotiate several significant migration barriers before reaching upstream habitats. Trout are known to prey directly on native species, and are likely to compete significantly for food and other resources.

The numbers of brown trout captured varied. Catch rates for the Gordon River monitoring sites were consistently higher in December 2001 than in April 2002 (paired T-test, p=0.0009). The catch per unit effort (CPUE) values are shown in Table 9.4. This pattern was not displayed for the adjoining tributaries of the Gordon (Table 9.4), with no clear relationship between month and CPUE.

These patterns indicate that conditions in the Gordon River itself were more favourable for brown trout in December 2001 than April 2002. As this relationship was not evident in the tributaries, it suggests that the flow regime preceding the December monitoring was more conducive to either the fish themselves or to their capture by backpack electrofishing than it was for the April survey.

Table 9.4. Catch Per Unit Effort (fish per 1200 seconds) for *S. trutta* in the Gordon River and tributaries.

Zone	River Dec-01	River Apr-02	Tributary Dec-01	Tributary Apr-02
1	0.74	0.20	1.29	3.15
2	5.34	2.11	3.77	2.15
3	7.50	1.62	8.98	10.58
4	3.24	2.26	7.93	5.30
5	2.08	0.94	1.77	2.23

Trout were not captured from the Birches Inlet rivers during the current study, nor were they captured during the 1999-2000 study (Howland *et al.* 2001). They were, however, present in the Henty River in significant numbers during the monitoring survey, particularly during December 2001.

Figure 9.2 shows the length-frequency distribution for brown trout caught in Gordon River Zones 1 - 5 during the December 2001 and April 2002 monitoring. As indicated previously, CPUE and total numbers captured were lower in the April 2002 survey than in the December 2001 survey. The size range of fish captured in December was also marginally broader, and may reflect the recruitment of a juvenile cohort into the sampled population.

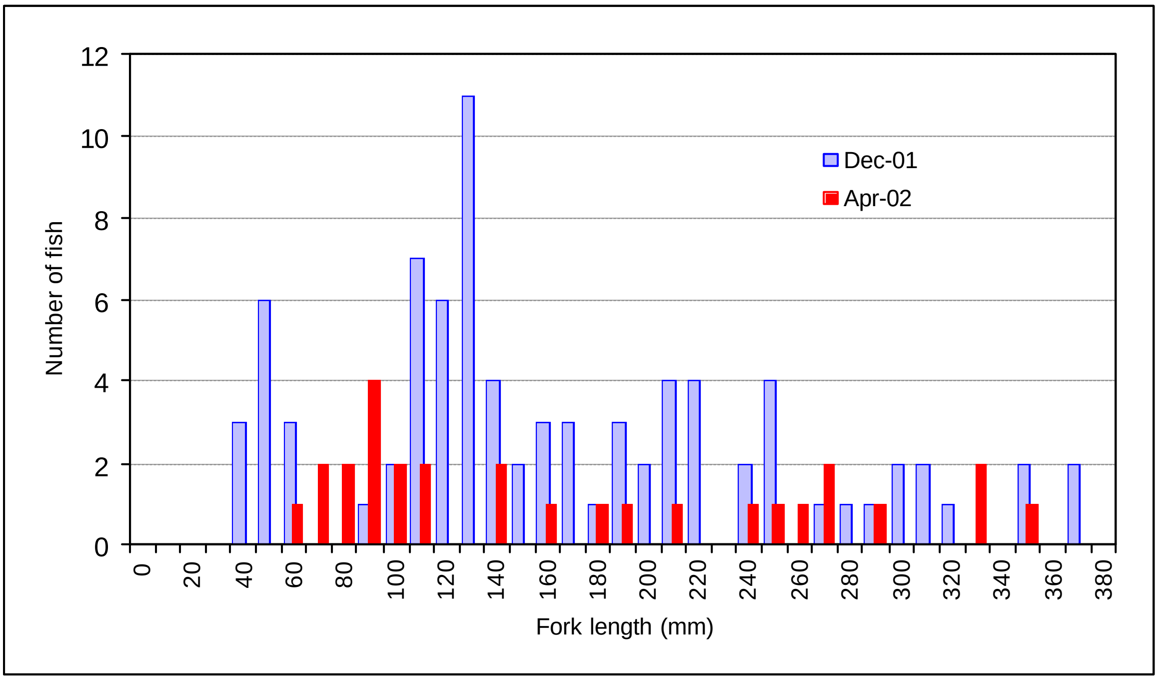


Figure 9.2. Length-frequency of *Salmo trutta* captured in the Gordon River from Zones 1 – 5 during the December 2001 (n = 83) and April 2002 monitoring (n = 28).

Figure 9.3 shows the length-frequency data pooled from December 2001 and April 2002. The data were divided by position relative to the Splits (Zones 1- 2, upstream vs Zones 3-5, downstream) to examine the assumption that brown trout population structure between zones is unlikely to be affected by migratory barriers along the Gordon River.

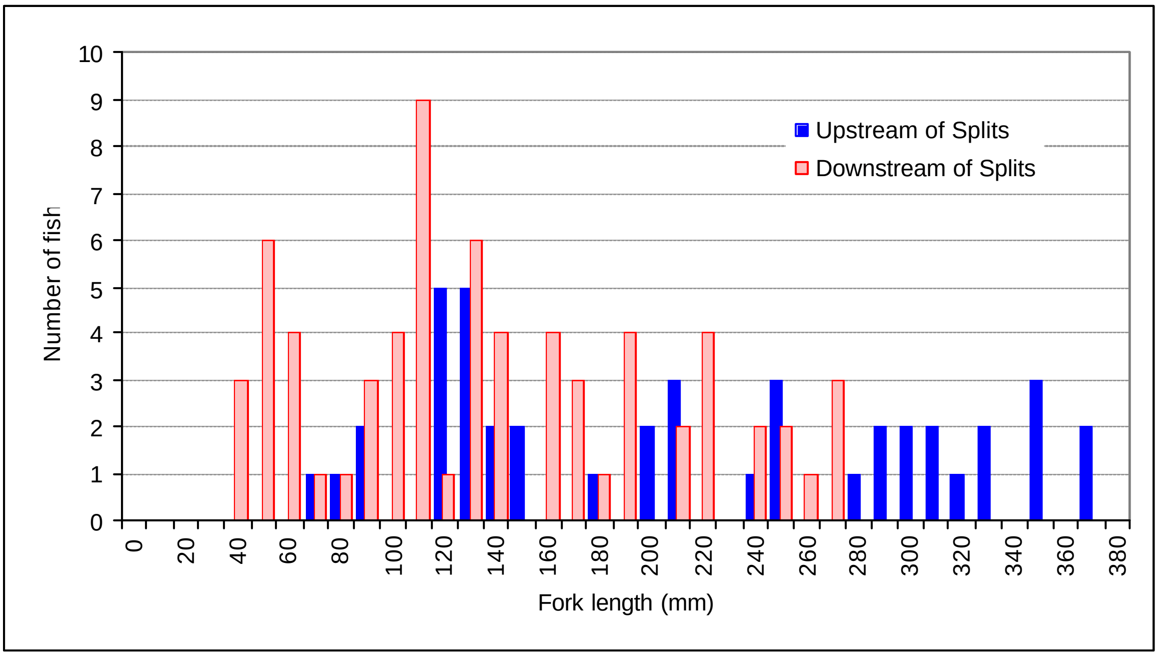


Figure 9.3. Length-frequency of *Salmo trutta* captured in the Gordon River from upstream (Zones 1 – 2) and downstream (Zones 3-5) of the Splits during the December 2001 (n = 43) and April 2002 monitoring (n = 68).

The size range of brown trout from the upper two zones appears to be displaced upwards compared to that of Zones 3-5. This pattern probably reflects the dominance of trout and reduced competition for resources in the upper reaches of the river. It may also reflect the vulnerability of larger trout to capture by electrofishing in the isolated and dewatered backwater habitats of upper Zone 2, rather than the effects of migratory barriers along the river. To date all brown trout caught in the surveys have been river residents, with no sea run trout observed or captured.

9.3.1.2 Redfin perch

The other exotic species collected during the 2001-02 monitoring, redfin perch (*Perca fluviatilis*), had not previously been recorded from the Gordon River below the Gordon Dam. It was first detected during the December 2001 monitoring, with one live specimen captured at Site 69 (G6), just upstream of the Second Splits, and two partially buried, somewhat decomposed specimens found on the riverbank near the Serpentine River junction. No other redfin were located at that time despite significant survey effort.

The April 2002 monitoring recorded higher catches, effectively confirming the presence of redfin perch in significant numbers. These fish were restricted to Zones 1 and 2 (Table 9.5), and ranged in size from 127 to 193 mm. It is assumed that these fish originated from the Lake Gordon stock.

Table 9.5. Capture locations and numbers caught for redfin perch (*Perca fluviatilis*).

Site	**Dec-01**	**Apr-02**
Zone 1		
Gordon @ Serpentine	*2	0
Site 76 (Gordon @ G2)	N/S	0
Site 75 (Gordon @ G4)	0	0
Site 74 (Gordon @ G4a)	0	0
Site 73 Gordon @ G3, u/s)	0	0
Site 73 (Gordon @ G3, d/s)	0	2
Zone 2		
Site 72 (Gordon @ G5, upper)	0	7
Site 72 (Gordon @ G5, lower)	0	2
Site 71 (Gordon @ G5a, pipe)	0	0
Site 71(Gordon @ G5a, water)	0	2
Gordon @ Grotto Creek	N/S	0
Site 69 (Gordon @ G6)	1	N/S

Notes: *stranded on river bank; N/S not monitored.

The presence of this new exotic piscivorous species, should it become established, is likely to have a detrimental impact on the fish communities of the Gordon River and, should they become more widespread, in the tributaries and possibly elsewhere in the Macquarie Harbour catchment. Redfin are currently absent from the reference sites monitored in this study.

9.3.2 Eels and lampreys

9.3.2.1 Short headed lampreys

The short-headed lamprey (*Mordacia mordax*) was not recorded from the Gordon River during the December 2001 and April 2002 surveys. It was, however, found in very low numbers in the Franklin River, one of its tributaries, and the Pocacker River (Birches Inlet). It is not known why this species is found in such low numbers, although it is clear that it has a wide distribution as shown by previous surveys (Howland *et al.* 2001).

9.3.2.2 Pouched lampreys

Pouched lampreys (*Geotria australis*) were captured in Zone 5 in the December 2001 monitoring, were recorded from Zones 3 to 5 of the Gordon River during the April 2002 monitoring, and were found relatively abundantly within other waterways. Catch rates for *G. australis* showed clear seasonal variation between samples, with a higher CPUE recorded in the Gordon River during April 2002, as shown in Table 9.6.

Interestingly, both lamprey species have been captured upstream of Sunshine Gorge and hence do not appear to be permanently restricted from passage past this barrier. However, no lampreys were captured in Zones 1 and 2 (upstream of the Splits) during the 2001-02 monitoring, supporting the earlier observations of Howland *et al.* (2001). No analysis of flow regimes in relation to this has been undertaken, but it is suspected that the high utilisation of the Gordon Power Station in recent years may have precluded upstream passages of lampreys.

Table 9.6. CPUE (standardised to fish per 1200 seconds) for *G. australis* in the Gordon and Franklin Rivers.

Zone	Dec-01	Apr-02
Zone 1	0	0
Zone 2	0	0
Zone 3	0	4.55
Zone 4	0	1.29
Zone 5	1.66	2.11
Franklin d/s Big Fall	0	2.74
Franklin u/s Big Fall	0	0

Figure 9.4 shows the length-frequencies of pouched lampreys captured during the December 2001 and April 2002 monitoring. Although relatively low numbers were caught, examination of histogram and field observations indicates that captured individuals were found in both the ammocete stage and macrothalmia stage of the species' juvenile life cycle. They ranged in size between 30 and 115 mm. *G. australis* remain as ammocetes until they reach a body length of about 100 mm (Fulton, 1990) prior to passage into the macrothalmia stage. Adult migrant pouched lampreys are usually around 600 mm long. It is interesting to note that the April 2002 monitoring captured the widest size range of individuals and recorded a higher CPUE than the December 2001 sample, which may reflect the development of an increasing proportion of juveniles into the macrothalmia stage.

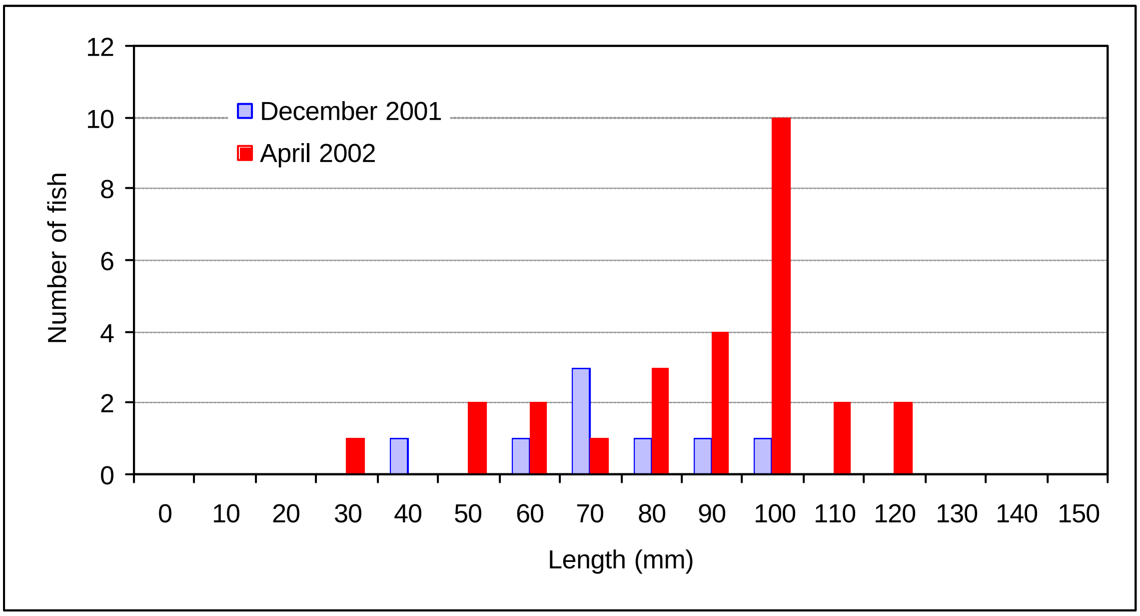


Figure 9.4. Length-frequency of *Geotria australis* captured in the Gordon River from Zones 3 – 5 during the December 2001 monitoring (n = 8) and the April 2002 monitoring (n = 27).

9.3.2.3 Short-finned eels

The short-finned eel (*Anguilla australis*) was found throughout the middle reaches of the Gordon River, with highest abundances in the downstream zones. Table 9.7 shows that, in these lower reaches, the CPUE for this species was not significantly different between the December 2001 and April 2002 samples (paired T test, p=0.88). The relatively lower numbers captured in the upstream zones prevented any meaningful comparison between monitoring trips. One stranded, live short-finned eel was collected from a gravel bar in Zone 1.

Table 9.7. CPUE (fish per 1200 seconds) for *A. australis* caught in the Gordon and Franklin Rivers in 2001-02.

Zone	Dec-01	Apr-02
Zone 1	2.22	0.20*
Zone 2	0.38	0.00
Zone 3	1.99	0.97
Zone 4	4.05	3.56
Zone 5	5.19	6.32
Franklin d/s Big Fall	0.38	4.52
Franklin u/s Big Fall	1.06	3.58

Note: *stranded on river bank.

A. australis was captured in the Birches Inlet reference sites and, to a lesser extent, Henty reference sites. No consistent seasonal pattern was detected at these sites with the presently available data. Figure 9.5 shows length-frequency distribution for data pooled from river Zones 1 to 5 from the December 2001 and the April 2002 monitoring. The former sample has a greater size range and a marginally higher proportion of larger eels, however more data are needed to expand on the reasons for this.

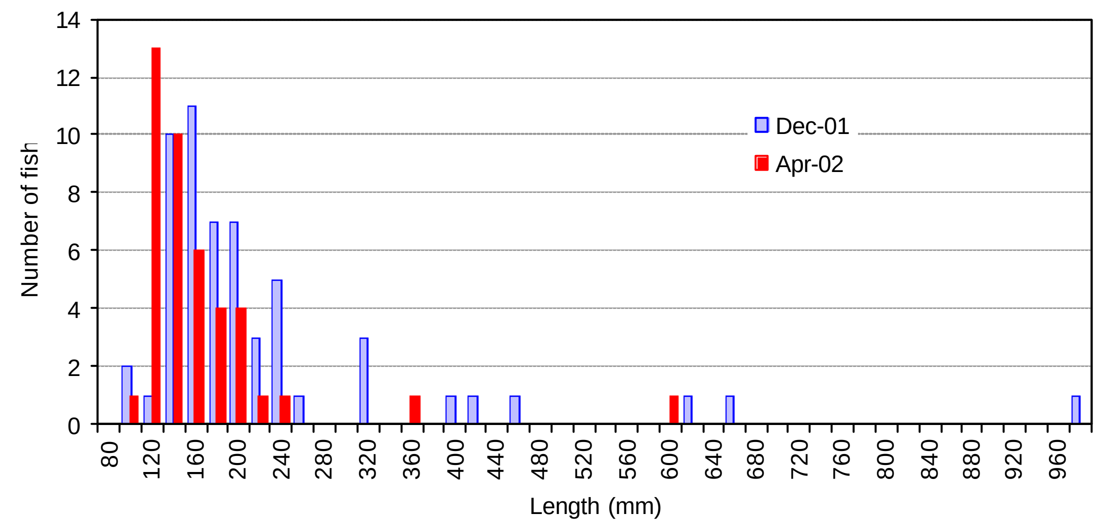


Figure 9.5. Length-frequency of *Anguilla australis* captured in the Gordon River from Zones 1 – 5 during the December 2001 survey (n = 56).

A. australis is diadromous and in-stream barriers may affect recruitment and upstream dispersal of the species. Figure 9.6 shows the length-frequency distributions for *A. australis* combined for both December 2001 and April 2002 and divided relative to the river's main migration barrier, the Splits.

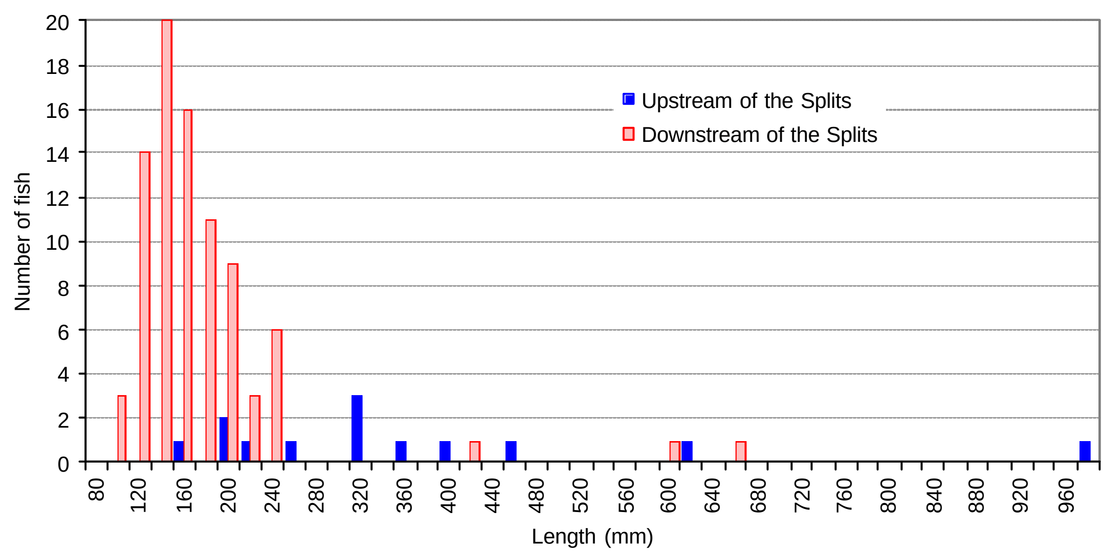


Figure 9.6. Length-frequency of *Anguilla australis* captured in the Gordon River from upstream (Zones 1 – 2: n = 13) and downstream (Zones 3 – 5: n= 85) for the combined December 2001 and April 2002 monitoring).

Although the catch numbers are low for Zones 1 and 2, inspection of these histograms combined with assessment of CPUE data show longitudinal differences in *A. australis* abundance and population structure, with fewer, larger eels generally inhabiting the upper zones.

9.3.3 Galaxiids and Sandys

Table 9.8 provides a summary of CPUE for galaxiids and sandys captured in the individual Gordon River zones during the December 2001 and April 2002 monitoring. Catch data indicated that the spatial distribution of the three galaxiid species (*G. truttaceus*, *G. brevipinnis*, and *G. maculatus*) and sandys (*P. urvillii*) were similar to those observed by Howland *et al.* (2001).

All galaxiid species were absent from the Gordon River in Zones 1-3, while *G. truttaceus* were present in Zones 4 and 5. *G. brevipinnis*, *G. maculatus* and *P. urvillii* were caught only in the lowest Gordon River survey reach, Zone 5.

G. truttaceus and, to a lesser degree, *G. brevipinnis* were present in low numbers in several Zone 3 and Zone 4 tributary streams, while *G. brevipinnis* was the only galaxiid present in the Zone 1 tributaries. Table 9.9 shows the CPUE values recorded during December 2001 and April 2002 for the Gordon tributaries.

All four species were captured in the Franklin River, although the small amount of data prevent any further examination of distributional patterns. Table 9.10 lists the sites and CPUE values for the Franklin River sites.

Only *G. truttaceus* and *G. brevipinnis* were recorded in the Franklin tributary sites, as shown in Table 9.11.

Table 9.8. CPUE for galaxiids (*G. brevipinnis*, *G. maculatus*, *G. truttaceus*) and sandys (*P. urvillii)* captured in the Gordon River during December 2001 and April 2002.

Zone	Species	Dec-01	Apr-02
Zones 1 - 3	All (galaxiids and sandys)	0	0
Zone 4	*G. brevipinnis*	0	0
	G. maculatus	0	0
	G. truttaceus	0.81	0.64
	P. urvillii	0	0
Zone 5	*G. brevipinnis*	0	0.47
	G. maculatus	0.42	2.34
	G. truttaceus	4.98	3.98
	P. urvillii	2.91	2.34

Table 9.9. CPUE for galaxiids (*G. brevipinnis*, *G. maculatus*, *G. truttaceus*) and sandys (*P. urvillii*) captured in the Gordon River tributaries during December 2001 and April 2002.

Zone	Species	Dec-01	Apr-02
Zone 1	*G. brevipinnis*	8.07	1.75
Zone 2	All (galaxiids and sandys)	0	0
Zone 3	*G. truttaceus*	0	0.12
	P. urvillii	0.18	0
Zone 4	*G. brevipinnis*	0.28	0
	G. maculatus	0	0
	G. truttaceus	4.53	1.56
	P. urvillii	0.28	0.31
Zone 5	*G. brevipinnis*	0	0
	G. maculatus	0	3.35
	G. truttaceus	2.95	2.23
	P. urvillii	1.18	3.35

Table 9.10. CPUE for galaxiids (*G. brevipinnis, G. maculatus, G. truttaceus*) and sandys (*P. urvillii*) captured in the Franklin River during December 2001 and April 2002.

Zone	Species	Dec-01	Apr-02
Zone 7 (Franklin d/s Big Fall)	*G. brevipinnis*	9.73	0
	G. maculatus	0	0
	G. truttaceus	0	2.74
	P. urvillii	3.24	2.74
Zone 8 (Franklin u/s Big Fall)	*G. brevipinnis*	1.33	0
	G. maculatus	0	0
	G. truttaceus	0.53	0.45
	P. urvillii	0.27	0.45

Table 9.11. CPUE for galaxiids (*G. brevipinnis*, *G. maculatus* , *G. truttaceus*) and sandys (*P. urvillii*) captured in the Franklin River tributaries during December 2001 and April 2002.

Zone	Species	Dec-01	Apr-02
Zone 8 (Franklin u/s Big Fall)	*G. brevipinnis*	1.61	1.28
	G. maculatus	0	0
	G. truttaceus	4.02	2.87

9.3.3.1 Climbing galaxias

Howland *et al.* (2001) reported climbing galaxias (*G. brevipinnis*) in Zone 1. Remnant populations of mature *G. brevipinnis* were again found in the Zone 1 tributaries, including Indigo Creek, during both surveys, and in the Serpentine River and Left Bank Creek at site 75 in the December 2001 monitoring. Catch rates were substantially lower in the April monitoring, however the reasons for this are not clear. Figure 9.7 shows the length-frequency distribution for *G. brevipinnis* captured in Zone 1 tributaries during December 2001.

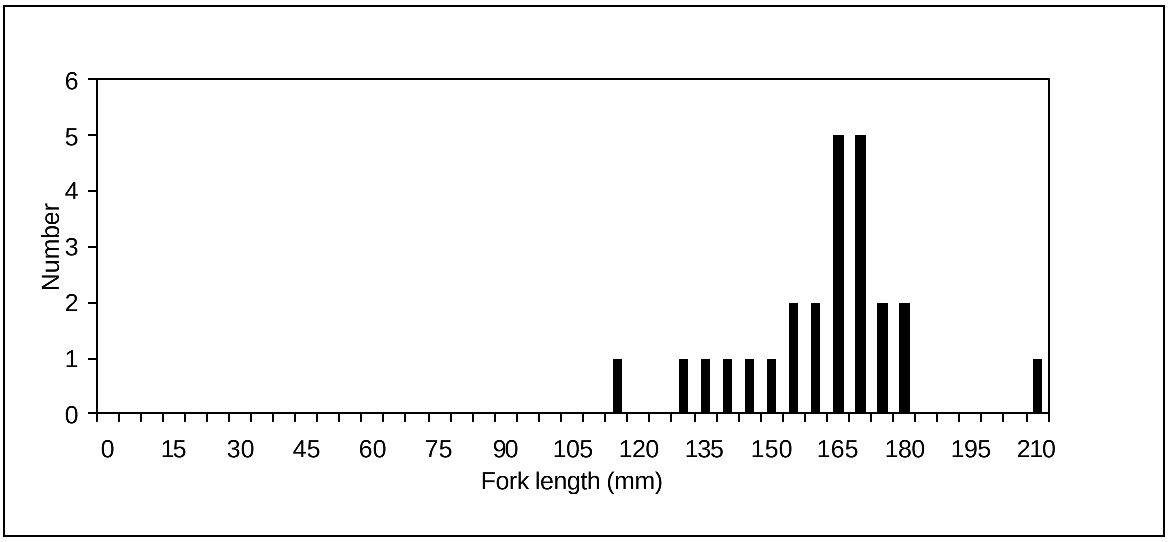


Figure 9.7. Length-frequency of *Galaxias brevipinnis* caught in Zone 1 tributary streams during December 2001 (n = 25).

The data for April 2002 have not been included as only five *G. brevipinnis* were caught. However, the size range was similar to the December 2001 data, indicating that no detectable recruitment had occurred between the December 2001 and April 2002 surveys.

An influx of small *G. brevipinnis* (45-53 mm) was recorded in the Franklin River (Zones 7 and 8) during the December 2001 monitoring, presumably as a result of recruitment from white bait stocks. However the lower Gordon regions (Zones 4 and 5) did not reflect this pattern. Data from the Gordon and Franklin Rivers and their tributaries suggest that catch rates were generally higher in December 2001 compared to April 2002, although there were insufficient data to test this relationship statistically. Small numbers of *G. brevipinnis* were reported from the Birches Inlet and Henty River sites during 1999 – 2000 (Howland *et al.*, 2001) and again during this year's monitoring.

9.3.3.2 Spotted galaxias

Figure 9.8 shows the length-frequency-distribution of spotted galaxias (*Galaxias truttaceus*) in the Gordon River Zones 4-5 for the December 2001 and April 2002 monitoring. Zones 1-3 were not included in the analysis as *G. truttaceus* were not captured in these areas.

Similar numbers of fish were caught during each survey. However, there appears to be a higher proportion of smaller fish in the April 2002 sample. This, combined with a bimodal length-frequency distribution, may represent galaxiids that successfully recruited from whitebait runs in 2001. In contrast, it is notable that catch data provided no evidence that recruitment had recently occurred to Zone 3 and Zone 4 tributary populations of *G. truttaceus* or *G. brevipinnis*.

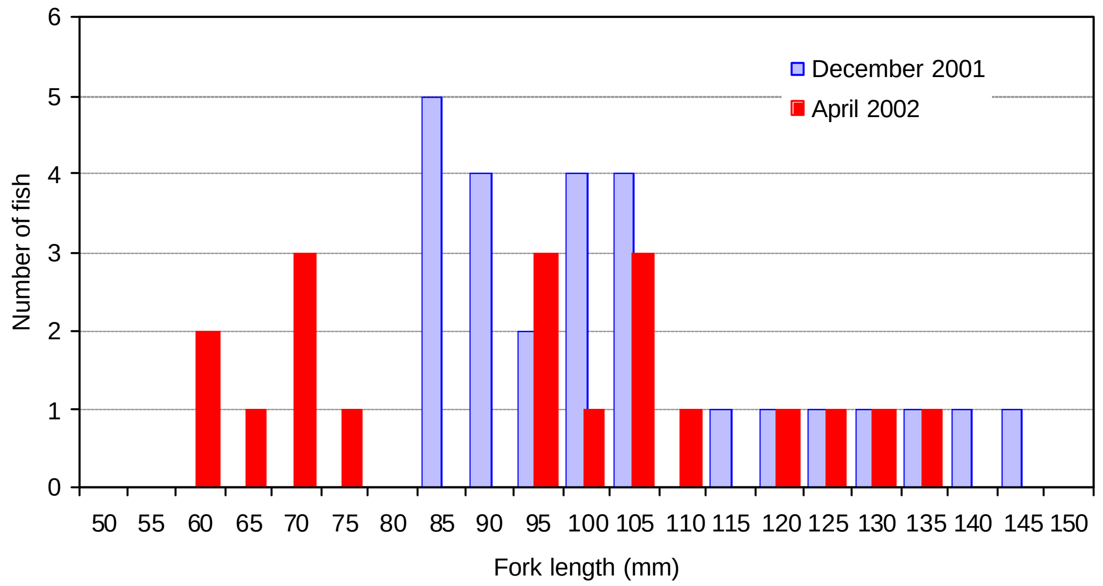


Figure 9.8. Length-frequency of *Galaxias truttacius* captured in the Gordon River from Zones 4 – 5 during the December 2001 (n = 26) and April 2002 monitoring (n = 19).

Catch rates of *G. truttaceus* in the Gordon and Franklin tributaries appeared higher in December 2001 than April 2002, however no such pattern was evident in the data from river sites. Conversely, catch rates at Birches Inlet and Henty River zones were higher in April 2002. There were insufficient data to test for statistical significance between seasonal catch rates.

9.3.3.3 Jollytails

Jollytails (*Galaxias maculatus*) were not captured from any of the Gordon or Franklin tributary sites, but were present in the lowest Gordon and Franklin river zones at relatively low catch rates, with April 2002 returning marginally higher CPUE values in comparison to December 2001. Low numbers were captured from the Henty River and Birches Inlet sites, with no obvious seasonal difference in catch rates. There were insufficient data to test for statistical significance between differences in seasonal catch rates.

9.3.3.4 Sandys

P. urvillii was present in Zone 5 of the Gordon River and Zones 7 and 8 of the Franklin River. They were also caught in the tributaries of Zone 4 in April 2002 and Zones 3 and 4 in December 2001, indicating that they can disperse moderate distances up the Gordon River under suitable conditions. Howland *et al.* (2001) reported sandys in Zone 5 of the Gordon River and several tributaries of Zone 4, so the 2001-02 monitoring has revealed that they occur further upstream in the Gordon catchment than previously thought.

Catch rates were high at the Birches Inlet sites during both monitoring trips, particularly during April 2002. These catches were the highest recorded for any species regardless of season. Low catch rates were recorded from the Henty River sites, with little seasonal difference evident.

9.3.4 Isolation and Competitive Interactions

As discussed in Howland *et al.* (2001), trout appear to be out-competing and displacing native species within the Gordon, particularly the upper zones of the river downstream of the Gordon Dam. This competitive interaction is not restricted to the main river, and is evident in some of the tributary streams.

The aging populations of *G. brevipinnis* in Indigo Creek and the Serpentine River are examples of populations that appear to have benefited from isolation from brown trout. However, they also appear to have suffered poor recruitment as a result of this isolation.

Further evidence of competitive interaction between trout and native species is also evident at other monitoring sites. Howland *et al.* (2001) described reaches of the Franklin and Henty Rivers where native species were not found in the same section of river as trout or, when they did occur together in a reach, the abundance of native species appeared to be reduced. Consequently, analysis of the catch data for longitudinal trends in native fish populations must take into account the potential for confounding interactions between galaxiids and trout. These may mask longitudinal changes occurring with the implementation of changed power station operating regimes under Basslink.

9.3.5 Fish stranding

Three stranded fish were collected during the 2001-02 monitoring; two partially decomposed redfin perch and one live short-finned eel. All stranded fish were collected from Zone 1. Given their partial state of decomposition and burial, the redfin probably died prior to their deposition. The results of the study to date indicate that fish stranding following power station shut down is uncommon.

9.4 Conclusion

The 2001-02 monitoring confirmed that brown trout are dominant in the middle Gordon River, particularly the upper reaches, and may show seasonal changes in catch rates related to the hydrology of the river.

Redfin perch were captured downstream of the Gordon Power Station for the first time during 2001-02. The impacts of the occurrence of an additional exotic species to the Gordon River depend upon its dispersal potential and ability to develop self-sustaining populations.

Numbers of the short-headed lamprey were markedly lower in the 2001-02 monitoring compared with the Basslink surveys conducted in 1999 and 2000. It is not clear why this is so. Pouched lamprey catches showed seasonal variation, with higher catches recorded in April 2002 survey, which may reflect a higher proportion of macrothalmia in catches.

The catch rate for short-finned eels did not appear to vary in between the December 2001 and April 2002 surveys. This species is able to access the length of the river up to Zone 1, although catch rates in the upper zones were lower relative to the downstream zones.

Three species of galaxiid were captured during the study. Notable results of the monitoring were that remnant populations of *G. brevipinnis* exist in several tributaries of Zone 1. *G. truttaceus* were restricted to the lower reaches of the study area, and were found in both river and tributary areas of the Gordon River. Some sites showed evidence of recent recruitment.

The monitoring confirmed that *G. maculatus* was confined to the lower reaches of the Gordon and Franklin Rivers, and was not found in their tributaries.

Sandy populations in the Gordon River appeared restricted to Zone 5, however a specimen was captured from a Zone 3 tributary indicating that they can successfully negotiate the Gordon River past Ewarts Gorge.

The results of the monitoring to date indicate that fish stranding following power station shut down is uncommon.

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