Hydro Tasmania
The power of natural thinking

Gordon River Monitoring Annual Report 2014–15

September 2015

Executive summary

This Gordon River Monitoring Annual Report presents the results of the monitoring undertaken from 13-15 October 2014 pursuant to the Gordon River Monitoring Program. Monitoring occurred approximately 1 week following the commencement of a one month long power station maintenance outage.

Hydrology

The flow in the Gordon River in 2014–15 was correlated with discharges from the Gordon Power Station with higher than average flows in July and-August 2014 and June 2015, while flows tended to be lower in summer compared to previous years. Flow patterns at downstream sites were generally reflective of discharges from the power station with the same distinctive annual pattern. In July-August 2014 and May-June 2015 there were a greater proportion of flows originating from tributaries following natural flow events.

The high flow hydrological triggers were exceeded in the previous monitoring year and early in the current monitoring year (July 2014) and led to this monitoring trip being undertaken in October 2014. In addition, one of the two peaking triggers (35-100 $m^3 s^{-1}$ peaking trigger) was exceeded late in June 2015. This exceedance triggers the requirement for a monitoring event, which will coincide with the biennial monitoring to take place in March 2016.

The application of the revised ramp-down rule was undertaken successfully in its third full year of implementation, with all generation reductions being compliant with the 1 MW per minute ramping requirements. Full compliance was achieved as the generation control system automatically applied the rule whenever the conditions requiring its use were met. Short periods of generation reduction, where implementation of ramping was required, were in excess of the 1 MW per minute target (0.51%) due to intrinsic operational factors or unforeseeable machine trips. These occurrences are not considered to be non-conformances as they were outside of operational control.

The bank saturation model which is used to predict in-bank water levels and to provide the trigger for application of the ramp-down rule was assessed using data collected since implementation of the model, and indicated that the model operated within expectations. There were a small number of false negative predictions as the model has a tendency to slightly underestimate the bank saturation levels.

The minimum environmental flow was achieved 100% of the time, both in summer and winter.

Fluvial geomorphology

Geomorphology monitoring was completed between the Gordon Power Station and the confluence with the Franklin River. Monitoring results were consistent with the hydrology of the river between March 2014 and October 2014, which was characterised by prolonged periods of high power station discharge, with reduced discharge in the few weeks immediately prior to monitoring and a high natural flow event during the week prior to monitoring.

Field observations included the exposure of a ‘new’ sand bar at the upstream end of zone 2, which may be related to changed hydraulics associated with the increase in high power station discharge or an episodic erosion event in a tributary. Other observations included the continued loss of river-side vegetation and seepage and scour features on bank toes presumably due to a combination of prolonged inundation and slightly increased water levels associated with high power station discharge compared to pre- or post-Basslink monitoring periods. Mud veneers were present on many bank toes, and are attributable to high inflows following the power station shutdown.

The erosion pin results were consistent with the understanding of erosional processes operating in the middle Gordon River. Sites characterised by tea tree and associated root-mats experienced scour of the root-mat, and 'flattening' of the bank toe downslope of the area protected by the root-mat. Banks lacking tea-tree cover, characterised by seepage processes typically showed scour of the bank in the 2-3 turbine power station operating level and a reduction in the slope of the bank toe through seepage processes which are recorded as deposition by the erosion pins.

Photo-monitoring also captured changes consistent with the recent hydrology of the river. Changes included the additional loss of vegetation owing to the sustained high power station discharge, loss or movement of woody debris on bank faces and toes, and the erosion of root-mats on banks supporting tea tree.

Overall, the results were consistent with the present understanding of the relationship between power station operations and geomorphic processes in the Gordon River.

Macroinvertebrates

Macroinvertebrates were sampled as required under the Gordon Monitoring Program at eight sites in the Gordon River between the Gordon Power Station and the Franklin River junction. Five reference sites were also sampled in the Franklin, Denison and Jane Rivers.

Quantitative surber samples were used to generate data on key metrics of abundance of taxa, total abundances and diversity (as number of taxa), both at family level and at species level, for the aquatic insect orders Ephemeroptera, Plecoptera and Trichoptera (EPT). Rapid bioassessment samples were used to derive observed over expected (O/E) values for each site, using the single season models developed by Davies (unpub. rep.) for Tasmanian Hydro catchments.

Patterns and trends in benthic macroinvertebrate metric values were broadly similar to those observed in the four pre-Basslink years with the following substantial exceptions:

- A sustained reduction in the number and relative abundance of expected macroinvertebrate families in Zone 1; and
- A reduction in the number of EPT species in Zone 2.

Three metrics fell below their lower trigger bounds:

- the values of O/Epa and O/Erk for Zone 1 and the whole of river; and
- the number of EPT species in Zone 2 and whole of river.

The abundance of EPT continued to exceed the pre-Basslink upper bounds. This exceedance was consistent with observations in most post-Basslink years, but to a lesser degree. The increased abundance of EPT continues to indicate an improvement in condition relative to the pre-Basslink period.

The decline in some metrics is likely to be related to the sustained high flows in 2013-14.

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Acronyms and abbreviations

AEMO	Australian Energy Market Operator – founded in 2009 with NEMMCO as a founding entity
AETV	Aurora Energy Tamar Valley
AUSRIVAS	Australian River Assessment System
BBR	Basslink Baseline Report
EPT	Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies)
FLOCAP	Flow calculator application to convert station output to flow
IIAS	Basslink Integrated Impact Assessment Statement: Potential Effects of Changes to Hydro Power Generation
LOAC	Level of acceptable change
NEMMCO	National Electricity Market Management Company – incorporated into AEMO in 2009
O/E	is a biological index of the 'observed' to 'expected' ratio which describes the proportion of macroinvertebrate taxa predicted to be at a site under undisturbed conditions that are actually found at that site. O/E scores range between 0, with no predicted taxa occurring at the site, to around 1, with all expected taxa being observed (i.e. a community composition equivalent to reference condition).
O/Epa	the O/E value calculated using an AUSRIVAS model based on presence-absence data
O/Erk	the O/E value calculated based on rank abundance category data
RBA	rapid biological assessment - macroinvertebrate sampling protocol
WOR	whole-of-river

Glossary

Bray-Curtis index	a measure of assemblage similarity between sites/samples
Cavitation	the formation and subsequent collapse of vapour bubbles (cavities) within water moving at high velocity. Cavitation is responsible for the pitting of turbine blades.
Confluence	the location when two rivers or tributaries flow together
Environmental flow	water which has been provided or released for the benefit of the downstream aquatic ecosystem and broader environment
Full gate	is the discharge which produces the maximum amount of energy by the turbine
Geomorphic	the study of the earth's shape or configuration
GordonRatingApp	the stand alone application used for calculating discharge from the Gordon Power Station
GWh	gigawatt hours (10^9 watt hours) – a standard measure of energy equivalent to the production of one gigawatt of power for one hour
Hydrology	the study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks and in the atmosphere
Hydro-peaking	variable flow in power station discharge on a daily scale
Inundation	an area of vegetation or bank which becomes covered by water associated with flows from either an upstream dam or tributary input
m^3s^{-1}	cubic metres per second, units for the measure of flow rate
MW	megawatts (10^6 watts) - a standard measure of power
Post-Basslink	the period following commissioning of the Basslink interconnector
Pre-Basslink	the period prior to commissioning of the Basslink interconnector
Riffle habitat	habitat comprising rocky shoal or sandbar lying just below the surface of a waterway
Rill	a small brook or natural stream of water smaller than a river
Tailrace	the outflow structure of the power station, from which water is discharged into the river
Taxon	a taxonomic category or group, such as a phylum, order, family, genus, or species
Temporal	change or pattern over time

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1 Introduction and background

The purpose of this Gordon River Monitoring Annual Report is to present the results of the monitoring undertaken pursuant to the Monitoring and Reporting Conditions in the Hydro Tasmania's Special Licence Agreement. The high flow hydrological trigger was exceeded in 2013-14, requiring monitoring to be conducted in October 2014, the results of which are presented in this report.

This is the ninth year of post-Basslink operation. The monitoring area is shown on Figure 1-1.

1.1 Context

The aims of the original Gordon River Basslink Monitoring Program were to:

- undertake pre-Basslink monitoring (2001–05) in order to extend the understanding gained during the 1999–2000 investigative years on the present condition, trends, and spatial and temporal variability of potentially Basslink-affected aspects of the middle Gordon River ecosystem;
- undertake six years of post-Basslink monitoring to determine the effects of Basslink operations on the environment of the Gordon River below the power station and to assess the effectiveness of mitigation measures; and
- obtain long-term datasets for aspects of the middle Gordon River ecosystem potentially affected by Basslink that will allow refinement of theories and more precise quantification of spatial and temporal variability, processes and rates.

The focus of the pre-Basslink monitoring program was to measure conditions under the existing operating regime, rather than attempting to relate them to 'natural' or 'pristine' conditions. This approach was an essential element of the monitoring program given the highly modified conditions that exist due to the presence of, and the flow regulation resulting from, the Gordon Power Scheme.

A major component of the post-Basslink monitoring program was to compare post-Basslink data with trigger values derived from pre-Basslink data and to assess the effectiveness of two operational mitigation measures; a minimum environmental flow and a power station discharge ramp-down requirement (ramp-down rule). Six years of data were collected post-Basslink to that purpose..

The subsequent Gordon River Interim Basslink Monitoring Program comprised a monitoring regime for two years from May 2012 to April 2014 to assess the effectiveness of the mitigation measures (ramp-down rule and minimum environmental flow). The commitment to continue monitoring beyond the original period was due to the revision of the ramp-down rule in mid-2012 which better aligned operational and environmental objectives. It was considered prudent to ensure that the aims of the revised ramp-down rule were being achieved, and monitoring continued with a focus on hydrology, fluvial geomorphology and macroinvertebrate disciplines.

The current Gordon River Monitoring focusses on hydrology, fluvial geomorphology and macroinvertebrate monitoring. The main aim of the current Gordon River Monitoring is to validate the conceptual models presented in the Basslink Review Report 2006-12 (Hydro Tasmania 2013) and improve our understanding of the responses when the power station is operating outside historical ranges. Monitoring is to be undertaken on a reduced scale on one occasion between February and April on a biennial basis in 2016, 2018 and 2020.

Additional monitoring is required if the following hydrological triggers are exceeded:

- Flow at Gordon Compliance site over a 90 day period exceeds:
  i. 100 m^3s^{-1} for more than 99% of the time; or
  ii. 200 m^3s^{-1} for more than 93% of the time; and
- Gordon Power Station discharge over a 90 day period rises from:
  i. 35 to 100 m^3s^{-1} in 4 hours or less on more than 75 occasions; or
  ii. 35 to 200 m^3s^{-1} in 4 hours or less on more than 40 occasions.

1.2 Basslink baseline and review reports

A requirement of Hydro Tasmania's Special Licence was to produce a Basslink Baseline Report (BBR) (Hydro Tasmania 2005a, 2005b) prior to Basslink commencement to provide a comprehensive assessment of pre-Basslink conditions in the Gordon River below the power station. The BBR described how post-Basslink conditions would be compared with the pre-Basslink ranges of variability and trends. The BBR consolidated and built upon knowledge gained through investigative studies undertaken during the Basslink approvals process.

Basslink Review Reports were produced in 2010 and 2013 (Hydro Tasmania 2010, 2013) and assessed the full datasets in greater detail than presented in the annual reports. The review reports included the assessment of the effectiveness of mitigation measures. The Basslink Baseline and Review Reports are available on Hydro Tasmania's website: www.hydro.com.au/environment/basslink-studies.

1.3 Logistical considerations and monitoring in 2014–15

Site 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, the absence of access to infrastructure and the extent of the study area.

Power station outages are needed to conduct monitoring because the majority of viable helicopter landing sites are on cobble bars in the river bed that are exposed only when there is little or no discharge from the power station. Outages are also necessary 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 normal or high flow conditions.

The 2014–15 monitoring field trip was conducted on 13-15 October 2014.

1.4 Geographic datum

Map coordinates in this document use the 1966 Australian Geodetic Datum (AGD) which corresponds to topographic maps currently available for the area. A later datum, the Geocentric Datum for Australia (GDA), was subsequently adopted for new maps. Site references using the AGD will be approximately 200 m different (-112 m east and -183 m north) from those using the GDA.

1.5 Document structure

The report is organised into four chapters and four appendices.

This first chapter discusses the requirements, context, logistical considerations and constraints of the program. Chapters 2–4 report on the monitoring work that was undertaken during 2014–15, and present the consolidated results of each of the individual monitoring elements. These are:

- Hydrology and water management (Chapter 2);
- Fluvial geomorphology (Chapter 3); and
- Macroinvertebrates (Chapter 4).

The report also contains the following four appendices;

- Power station discharges graphed per month (Appendix A);
- Ramp-down rule exceedence events (Appendix B);
- Fluvial geomorphology photo-monitoring (Appendix C); and
- Macroinvertebrate data (Appendix D).

1.6 Authorship of chapters

The information presented in chapters 2–4 is based on field reports produced by scientists employed to conduct the monitoring, as shown in Table 1-1. The efforts and original contributions of these researchers are duly acknowledged.

This document was collated by Malcolm McCausland (Entura), with review from Marie Egerrup and Greg Carson (Hydro Tasmania), and significant assistance from the researchers.

Table 1-1: Chapter numbers, titles and original authors from whose reports the information in chapters 2–4 was extracted.

Chapter	Chapter title	Lead Author(s)
2	Hydrology	Malcolm McCausland (Entura) and Roger Parkyn (Hydro Tasmania)
3	Fluvial geomorphology	Lois Koehnken (Technical Advice on Water)
4	Macroinvertebrates	Peter Davies and Laurie Cook (Freshwater Systems)

1.8 Site numbers

Throughout this report monitoring locations are identified by site number. These represent the approximate distance upstream from the Gordon River mouth at the south-eastern end of Macquarie Harbour. The monitoring work is conducted between sites 44 (immediately upstream of the Franklin confluence) and site 77 (the power station tailrace).

The fluvial geomorphology discipline uses zones rather than the standard site numbering system. This is because the work is associated with longer reaches of river bank than are suitable for the 'site' nomenclature.

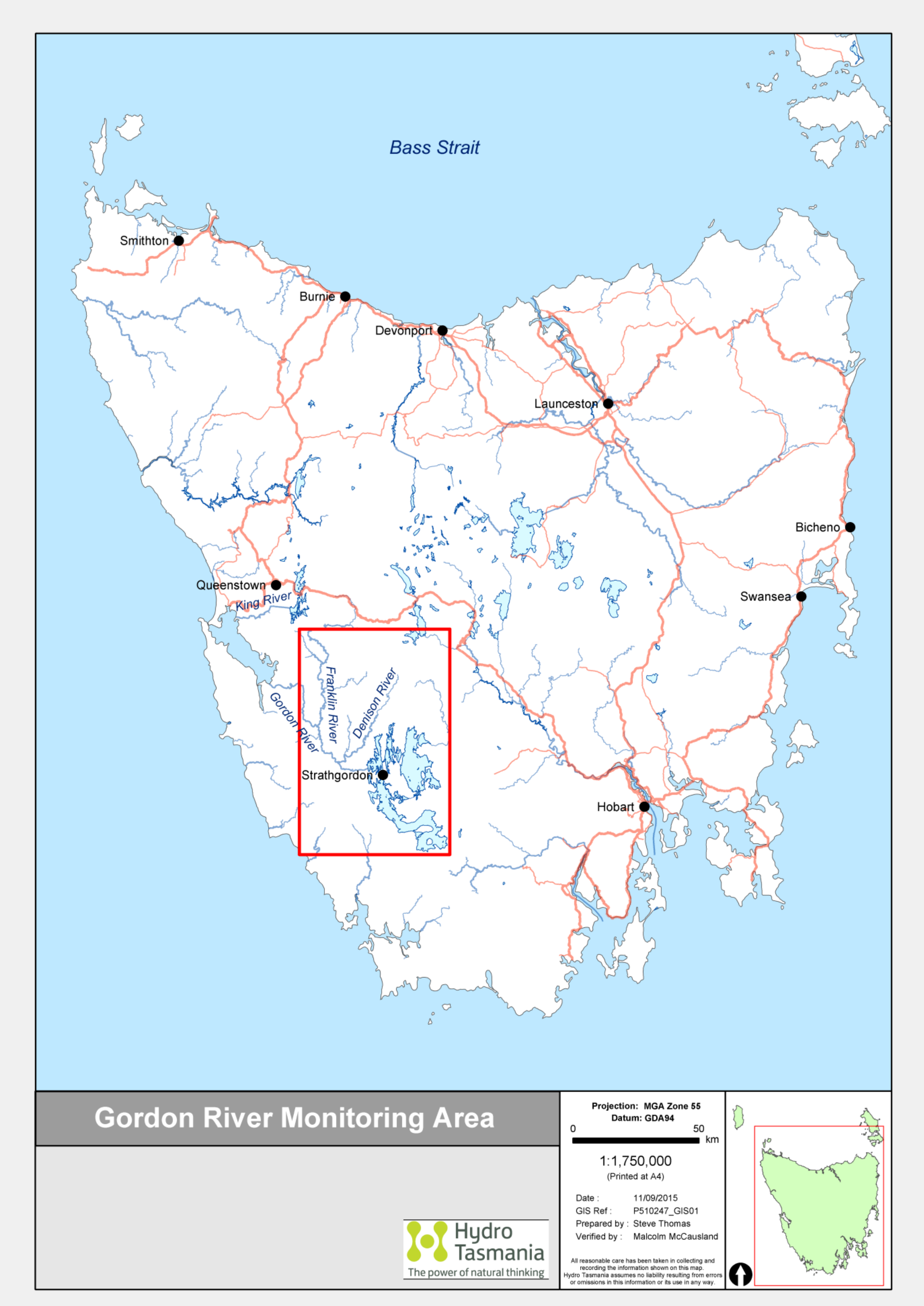

Figure 1-1: Gordon River monitoring area.

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2 Hydrology and water management

This chapter of the Gordon River Monitoring Annual Report provides an overview of the hydrological data from the Gordon River downstream of the Gordon Power Station for the period July 2014 to June 2015. Conformance with the two mitigation measures, namely the minimum environmental flow and the ramp-down rule, are presented. In addition, conformance with the newly developed hydrological triggers is presented.

2.1 Factors affecting Gordon Power Station discharge

An overview of previous hydro generation drivers in previous years is shown in Figure 2-1 to Figure 2-3. The Gordon Power Station running regime has always been heavily influenced by a number of factors. A timeline of some of the major factors is presented in Figure 2-1. These factors include:

- inflows to Hydro Tasmania catchments (volume, distribution and temporal variation);
- overall storage position, in particular, the storage positions of Great Lake and Lake Gordon;
- National Electricity Market price signals;
- energy supply/demand in Tasmania; and
- power station outages.

In all but five of the last 20 years, Tasmanian electricity demand was higher than the annual hydro energy yield (Figure 2-2). The annual energy yield has varied between years, which in combination with variable generation (Figure 2-3) has influenced the overall system storage (Figure 2-4).

Following very high generation in 2012-13 and 2013-14, system generation in the past year (2014-15) returned to lower levels (8,176 GWh) similar to the generation between 2006-07 and 2009-10. Gordon Power Station generation in 2014–15 (1,066 GWh) was less than half the previous year and 27% lower than the long term median generation (1,470 GWh). Similar hydro generation relative to yield in the Gordon catchment, Great Lake catchment and the combined Hydro Tasmania catchments, has resulted in little net change in these storages and the overall storage position in the past year (Figure 2-4).

A number of factors since commissioning Basslink have played differing roles in the power station discharge, and include:

- drought conditions and associated low water storages;
- major power station outages within the Tasmanian system;
- market conditions; and
- the influence of changes in the market associated with the carbon price carbon price was finalised.

The number and potential influence of factors on Gordon Power Station operation is very large, and the identification and quantification of the influence of these remains difficult to determine.

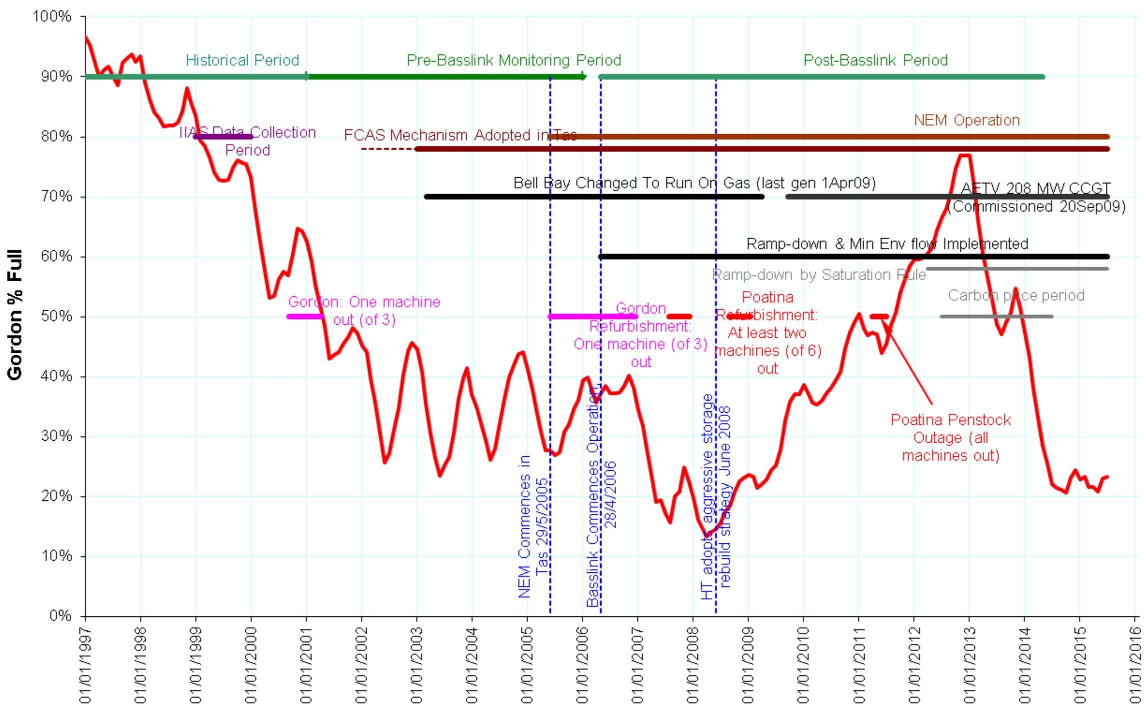

Figure 2-1: Timeline of significant factors affecting Gordon Power Station operation (including storage levels) relative to Basslink monitoring periods.

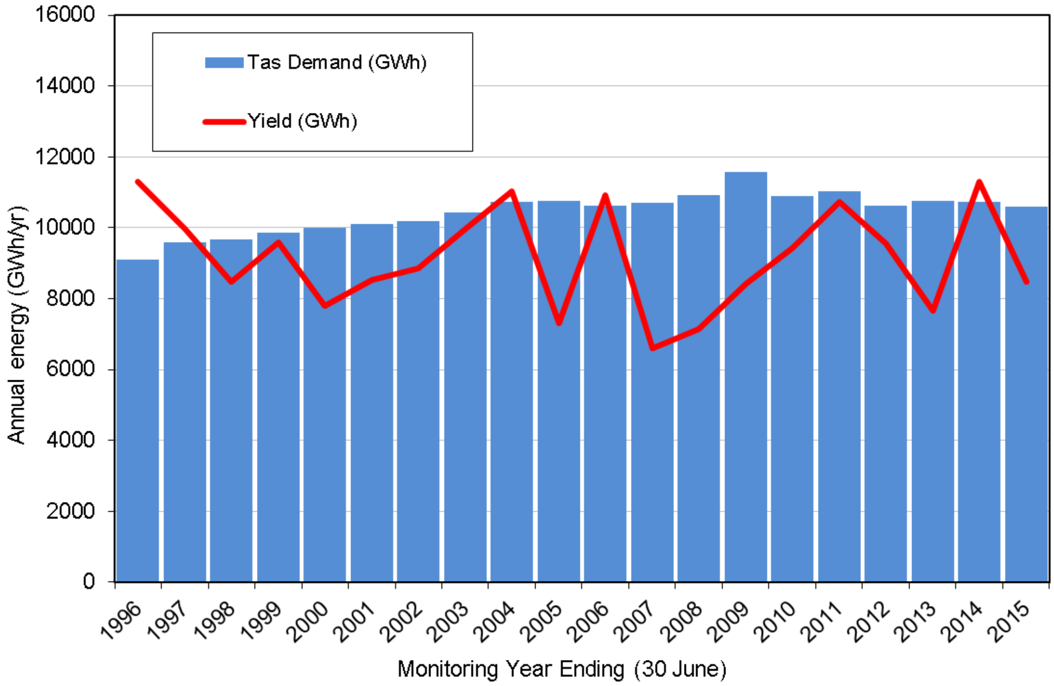

Figure 2-2: Annual Tasmanian electricity demand (total generation + import or total generation – export) and hydro energy yield representing system inflows converted to GWh.

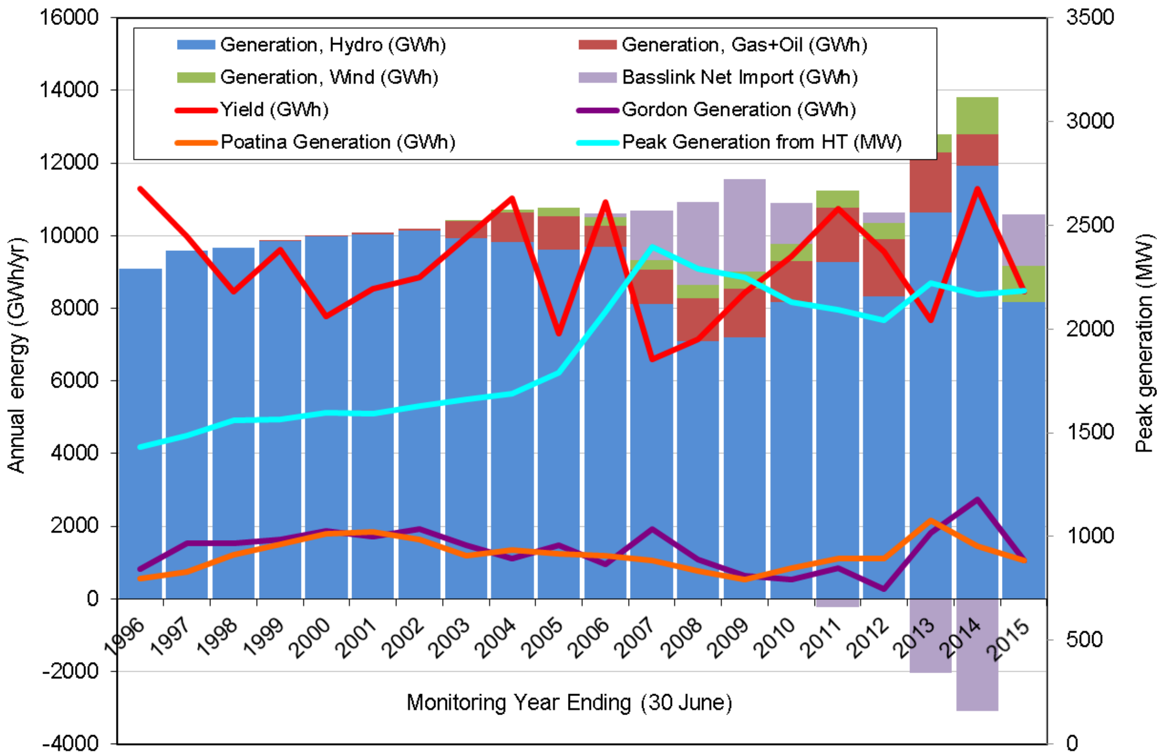

Figure 2-3: Hydro generation, wind and gas generation, Gordon and Poatina generation and net import (in GWh) and peak demand (in MW) for financial years from 1995–96 to 2014-15.

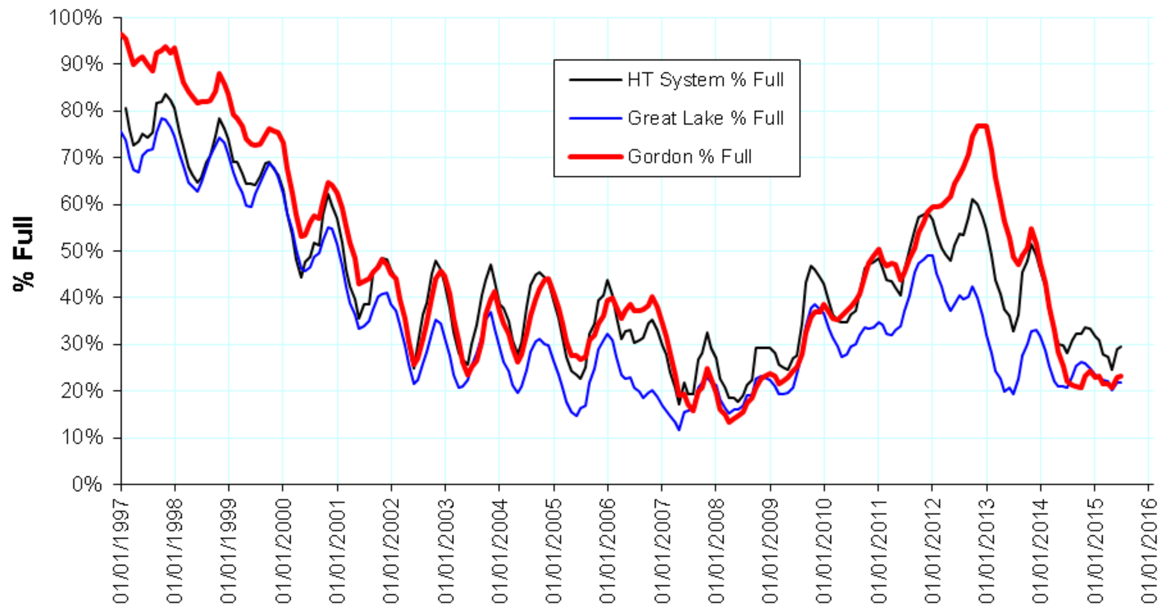

Figure 2-4: System, Lake Gordon and Great Lake water level presented as per cent full for 1997-2015.

2.2 Power output to flow ratings

Due to the difficulty in accurately measuring flow in the tailrace, flow records have been converted from power station output (MW) using a stand-alone rating application (GordonRatingApp). This application mimics the real-time tool used by the operators for the calculation of discharge from Gordon Power Station. It is the most accurate method of determining flow from the Gordon Power Station and is presented in all analyses in this report. This application utilises the following input data to determine discharge from Gordon Power Station:

- Individual machine output;
- storage water height; and
- machine power-discharge rating.

The application sends discharge data to the hydrological database for each five-minute interval.

2.3 Site locations

Power station discharge derived from the three-dimensional rating is used to estimate the flow in the tailrace (site 77). The flow monitoring sites reported in this chapter are from gauged sites at Gordon above Franklin (site 44), Gordon above Denison (site 65; also known as the flow compliance site) as well as the derived flow for Gordon Power Station tailrace (site 77).

A number of water level sites (sites 62, 69, 71 and 75), where water level data has previously been collected, were decommissioned in October 2014 as it was determined they are no longer required. The sites reported in this chapter (and those decommissioned) are shown in Figure 2-5.

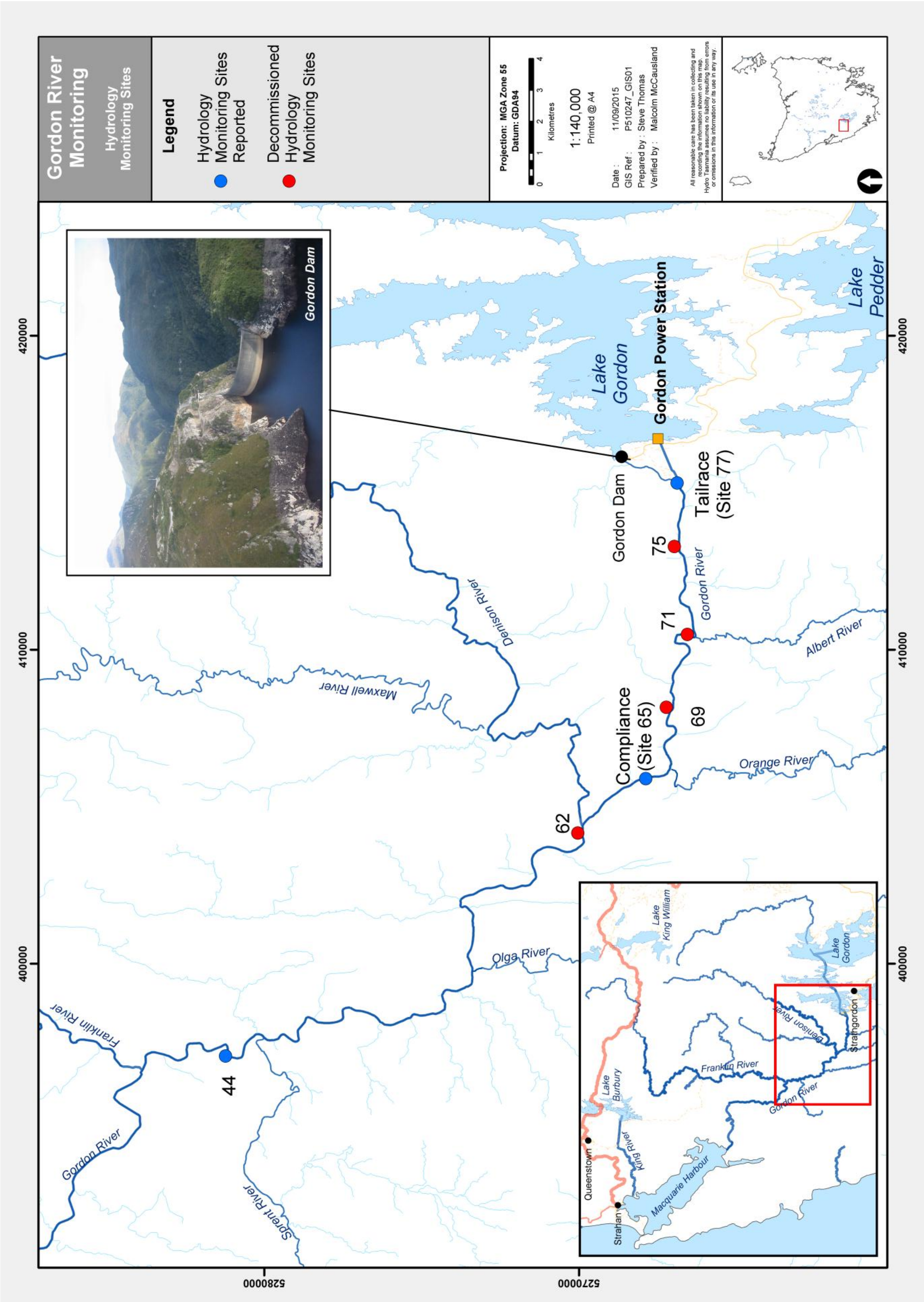

Figure 2-5: Gordon River hydrology monitoring sites.

2.4 Data analysis

2.4.1 General flow analysis

For 2014–15, the power station discharge at site 77 (the tailrace), site 65 (compliance site) and site 44 (Gordon above Franklin) hourly flow data, median monthly flow and annual duration curves were plotted (Sections 2.5.3, 2.5.4 and 2.5.5). These three sites are considered representative of the various river sections below the power station (data from sites 75, 71, 69, 62 were recorded hourly prior to their decommissioning in October 2014, but are not presented in this report).

Analyses at sites 77, 65 and 44 have provided the comparison of data from the 2014–15 year to the long-term average at that site. The long-term average is calculated by using all available data at a site, which means that the date range for the long-term average figures will change for each site depending on when data records commenced. Additional duration curves for the pre-Basslink, post-Basslink and historical periods, as well as each of the individual post-Basslink years, are presented for power station discharge data.

2.4.2 Hydrological triggers

An analysis of the exceedance of the hydrological triggers was undertaken for 2014-15 (Sections 2.5.3.5 and 2.5.4.5).

Exceedance of the hydrological triggers has the potential to impact upon macroinvertebrates and geomorphology, and are utilised to trigger a monitoring event in addition to the prescribed biennial monitoring. High flow triggers are indicative of a significant period of high flow, while peaking triggers are indicative of a significant degree of hydro-peaking.

2.4.2.1 High flow duration triggers

The high flow triggers are based on the flow measured at the Compliance Site (Site 65) in the previous 90 days and are exceeded when:

- flow is in excess of 100 m^3s^{-1} for 93 % (or more) of the preceding period; or
- flow is in excess of 200 m^3s^{-1} for 99% (or more) of the preceding period.

The analysis of the data identifies the following conditions at each hourly time-step:

- flow record for previous 90 days;
- duration analysis on the data set;
- determination of the percentile that each of the trigger flow values (100 or 200 m^3s^{-1}) constitutes for that period.

The data is presented in this report (Section 2.5.4.5) as a time-series of the percentile values of each of the trigger flows in the previous 90 day period.

2.4.2.2 Peaking triggers

The peaking triggers are based on discharge from Gordon Power Station (site 77) in the previous 90 days and are exceeded when discharge increases from:

- 35 to 100 m^3s^{-1} in 4 hours or less on more than 75 occasions; or
- 35 to 200 m^3s^{-1} in 4 hours or less on more than 40 occasions.

The analysis of the data utilises aggregated hourly data and identifies the following conditions:

- discharge reduced below 35 m^3s^{-1}; and
- subsequently increased to greater than 100 m^3s^{-1} (trigger 1) or 200 m^3s^{-1} (trigger 2) within a four-hour period; and
- counting the number of occurrences these events that have occurred in the previous 90 days.

The data is presented in Section 2.5.3.5 as a time-series of the number of occasions the peaking events have occurred in the past 90 days, and are compared to the trigger value.

2.4.3 Ramp-down rule

2.4.3.1 Background

A ramp-down rule mitigation measure has been in place at Gordon Power Station since the commissioning of Basslink in April 2006, under the terms of Hydro Tasmania's Special Water Licence Agreement. A revised and improved ramp-down rule was implemented from 1 April 2012. Its aim is to limit the rate of seepage erosion.

The revised rule utilises a Bank Saturation Regression Model to determine when the ramp-down rule is required to be applied. The Bank Saturation Regression Model utilises real-time discharge data from the Gordon Power Station to predict the level of saturation of the banks at Site 71 (Gordon River below Albert).

The rule is as follows:

- whenever the bank saturation level at site 71, as calculated by the Bank Saturation Model, is greater than 2.75 m above the local datum and the discharge from the Gordon Power Station is greater than 150 m^3s^{-1}, the plant control system must be set to control any reductions in generation load at a rate of 1 MW per minute until the power station discharge is less than 150 m^3s^{-1}.

2.4.3.2 Test of compliance with ramp-down rule

The rule requires the ramp-down rule (i.e. to set the plant control system generation to avoid reductions exceeding 1 MW per minute) be applied when both:

- bank saturation level (from the Bank Saturation Model) exceeds 2.75 m; and
- power station discharge exceeds 150 m^3s^{-1}.

Hence the testing approach identified such periods (on a 5-minute basis) and, for them, determined if the plant control system was in place. In addition, while the plant control system was in place, comparison was made between the actual generation change-rate with the -1.0 MW/minute target. The results of the compliance test is presented in Section 2.5.3.6.

2.4.3.3 Performance of Bank Saturation Model

The integral component for the implementation of the ramp-down rule is the Bank Saturation Model. Its continued good performance has been important to ensure that un-ramped flow reductions do not occur while saturation in the banks is high. A model performance assessment was undertaken to compare model outputs from the date of its first operation with the field data for which data is available (April 2012 to October 2014). As part of this assessment, the percentage of false positives (modelled values higher than actual level of 2.75 m) and false negatives (modelled values lower than actual level of 2.75 m) is reported in Section 2.5.3.8.

2.5 Results

2.5.1 Data availability

Sites 62, 69, 71 and 75 were decommissioned in mid-October. There was no missing data from the remaining sites (sites 77, 65 and 44) for the 2014-15 monitoring period.

2.5.2 General analysis

2.5.2.1 System yield

The inflows to Hydro Tasmania's state-wide system during the 2014–15 were below average levels. The total system inflows (system yield) of 8,466 GWh were 92 % of the long-term mean (1976–2014).

Figure 2-6 shows the total system yield during 2014–15 compared with the long-term (1976–2014) median, 20th and 80th percentile inflows.

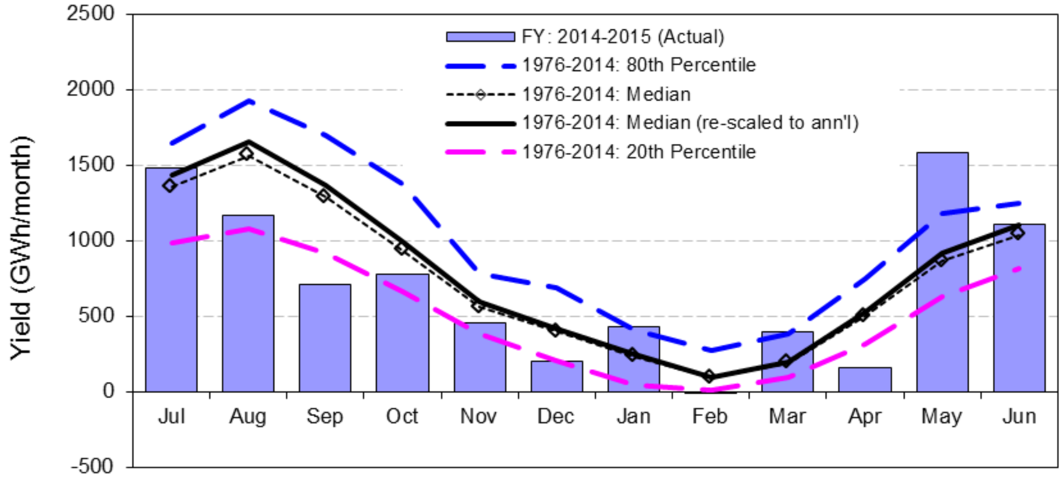

Figure 2-6: Monthly total system yield for 2014–15 compared to the long-term median, 20th and 80th percentiles for 1976–2014.

2.5.2.2 *Strathgordon rainfall*

The Strathgordon meteorological station has rainfall records beginning in 1970. These allow the calculation of long-term mean monthly values and comparisons with the monthly rainfall totals recorded for 2014–15.

Figure 2-7 shows the total monthly and long-term average monthly rainfall values. In 2014–15 it was an average year in Strathgordon receiving 2,474 mm. The annual rainfall (2,474 mm) was very similar to the long-term median (2,454 mm).

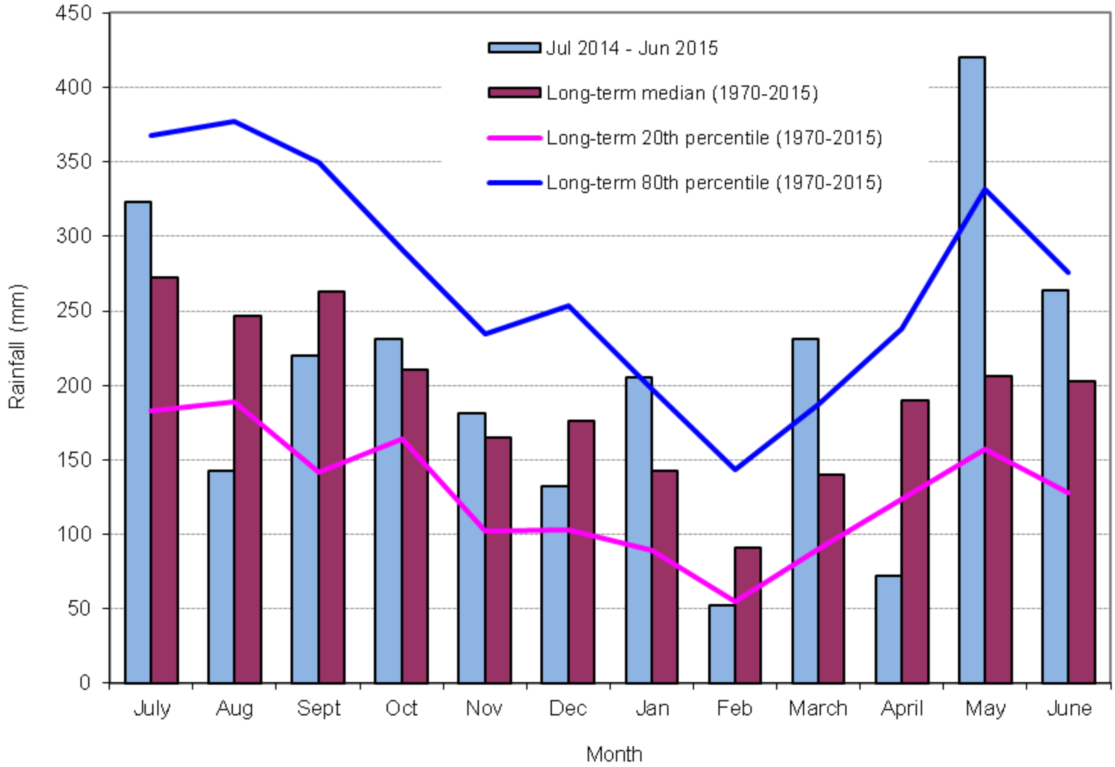

Figure 2-7: Total monthly rainfall values recorded at Strathgordon for 2014–15 compared with the long-term median (1970–2015).

2.5.3 Gordon Power Station operation

2.5.3.1 Discharge and power station operation

As previously discussed (see Section 2.1), the discharge pattern for the Gordon Power Station is driven by a number of factors. Figure 2-8 shows the discharge from the power station for 2014–15. More detailed monthly graphs are provided in Appendix A. A summary of significant points of interest in the 2014–15 discharge data is as follows:

- in July to mid-September 2014 the discharge pattern consisted of periods of peaking between high (>200 m^3s^{-1}) and low-mid range discharges (30-120 m^3s^{-1}) interspersed with a pattern of 2-3 turbine peaking with a small peak range of between 160 and 240 m^3s^{-1};
- for the remainder of September until early October 2013, the discharge was generally low, in the vicinity of the environmental flow, with occasional mid-range peaks in discharge;
- most of October 2014 had no discharge as a result of the power station outage, which was once again followed in November with low flow dominated pattern, with occasional mid-range peak;
- December 2014 was dominated by consistent mid-high range discharges (~140 m^3s^{-1}) in the first half of the month, and a more variable mid-high peaking pattern (70- 170 m^3s^{-1}) which continued into early January;
- The remainder January 2015 was dominated by low flow while February and March became increasingly characterised by a peaking pattern (30-200 m^3s^{-1}); and
- April, May and June were characterised by a high range (20 to >200 m^3s^{-1}) daily peaking pattern leading to exceedence of the peaking trigger at the end of June (see Section 2.5.3.5).

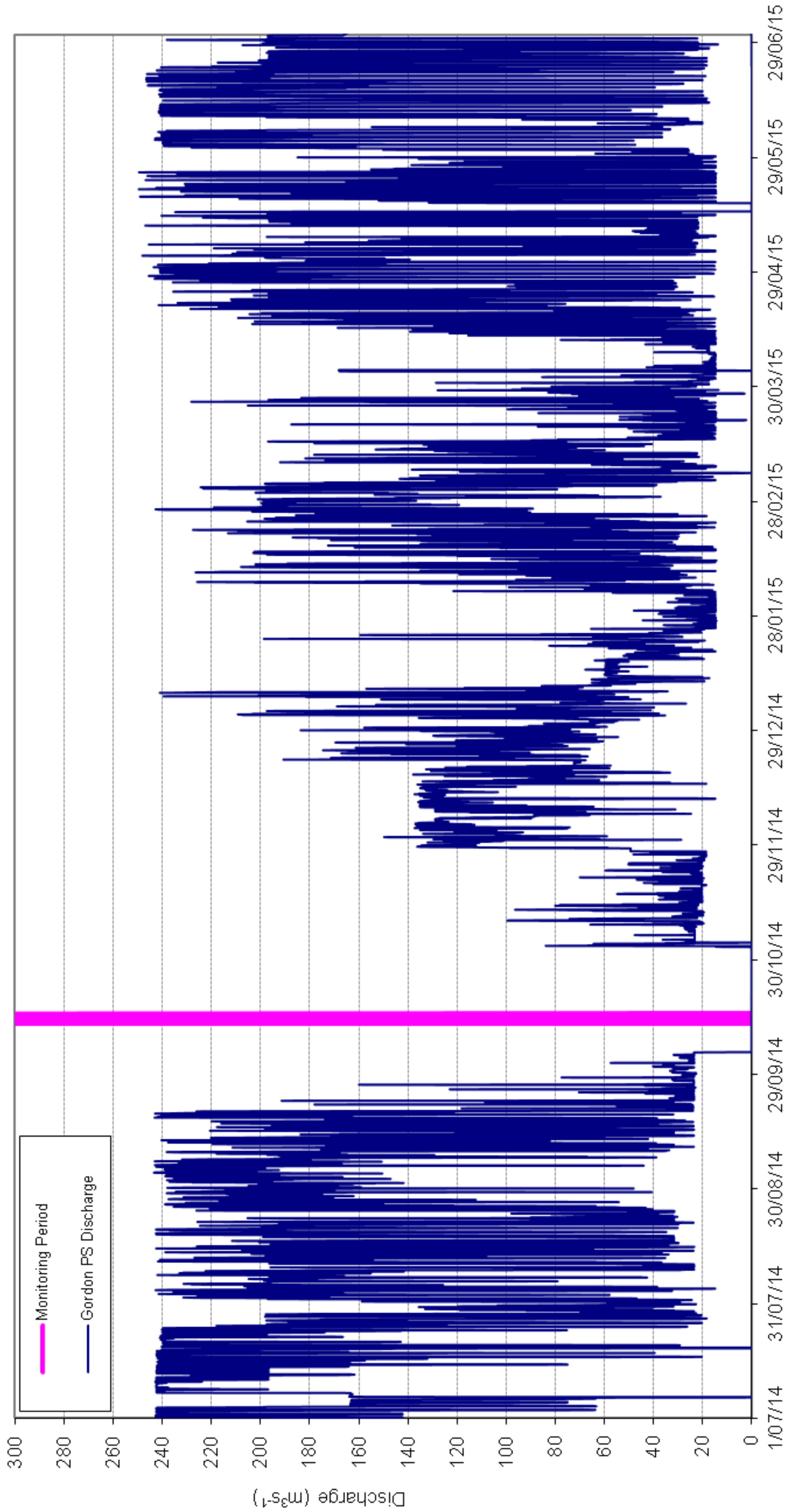

Figure 2-8: Gordon Power Station discharge (hourly data) from July 2014 to June 2015. Pink vertical line indicates the monitoring event.

Table 2-1: Summary information on discharge, weather conditions, market volatility and outages for 2014–15. Dry months are classified as months with values lower than the 20th percentile of the long-term values, and wet months are classified as months with values higher than the 80th percentile of the long-term values. Market volatility is based on daily average price and 30 minute prices.

Period	0-turbine operation % time	1-turbine operation % time	2-turbine operation % time	3-turbine operation % time	Strathgordon rainfall	System yield	Gordon operation and influential factors	Basslink Net Import (GWh) (negative = export, positive = import)
July 2014	1.1	8.1	22.3	68.5	> average	average	Gordon on high load to achieve high basslink exports. Two short station outages during the month	-172.3
August 2014	0.0	6.7	20.7	72.6	dry	< average	Gordon high average loading for first half of the month for Basslink exports	--55.3
September 2014	0.0	25.8	19.4	54.7	< average	<< average	Gordon high average loading at start of month, reduced to mainly minimum discharge in 2nd half of the month (related to Basslink imports))	118.3
October 2014	85.2	9.9	4.8	0.0	> average	< average	Gordon minimum load in first week Major station outage for remainder of month (no discharge)	172.0
November 2014	5.3	78.2	16.5	0.0	> average	< average	High import on Basslink for majority of the month produced Gordon average discharge near minimum after station returned from major outage	253.1
December 2014	0.0	1.3	71.6	27.0	< average	< average	Gordon high average loading with high average Basslink import due to reduced run of river generation elsewhere in Tasmania	307.2
January 2015	0.0	31.5	49.3	19.2	wet	> average	Gordon low average loading with high Basslink average import and increased run of river generation elsewhere in Tasmania.	216.5
February 2015	0.0	29.5	35.3	35.3	dry	< average	Gordon marginal for average loading with Basslink mostly at constrained import apart from some peaks.	234.3
March 2015	1.1	32.0	41.1	25.8	wet	> average	Gordon marginal for average loading with Basslink mostly at constrained import apart from some peaks.	300.9
April 2015	0.3	42.9	21.4	35.4	dry	<< average	Gordon mainly at minimum discharge for 1st half with high Basslink imports, peaking for the 2nd half.	217.4
May 2015	7.1	21.0	38.6	33.3	wet	>> average	Basslink outage 2/5 to 3/5. Gordon marginal for export on peaks for the remainder.	-52.1
June 2015	0.0	13.6	17.5	68.9	> average	average	Gordon marginal to maximum load on peaks.	-122.7

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2.5.3.2 Power station outages

There were ten power station maintenance and inspection outages in 2014–15. Nine of these were partial outages and only a few hours' duration. A major month-long four-yearly maintenance outage took place from 5 October 2014 to 3 November 2014. The monitoring was undertaken during this outage on 13–15 October 2014.

2.5.3.3 Median monthly discharge

Figure 2-9 shows the median monthly discharge from the power station for 2014–15 compared with long-term values (since January 1997) and the previous eight years of the post-Basslink period. The 2014-15 median values indicated an annual pattern that tended to differ from the long-term and other post-Basslink years. The lower flows occurred from mid-spring to autumn (October to May) when flows in previous years have tended to be higher. Similarly the high flows from July to September 2014 and June 2015 were substantially greater than those in previous years.

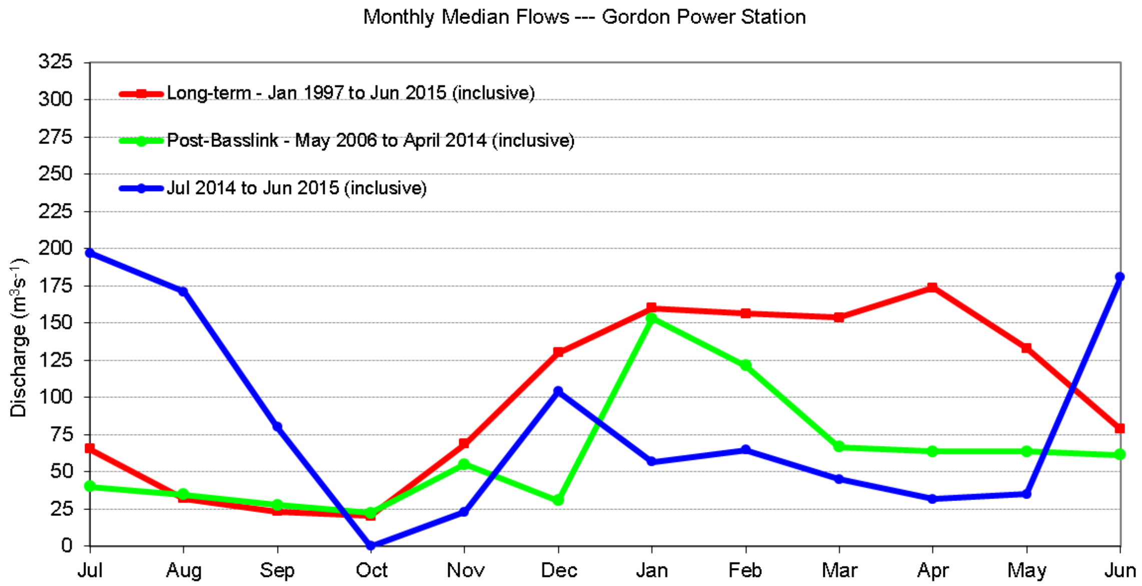

Figure 2-9: Median monthly discharge from the Gordon Power Station (site 77) for 2014–15 compared with long-term monthly median values and previous post-Basslink years.

2.5.3.4 Flow duration curves

Figure 2-10 to Figure 2-13 show the duration (percentage exceedance) curve for the power station discharge for:

- Whole of year (Figure 2-10);
- winter period (May–October; Figure 2-11);
- summer period (November–April; Figure 2-12); and
- years one to eight of post-Basslink annual data (Figure 2-13).

Various duration curves have been plotted against these periods (each period has been devised such that it is divisible by 12 months):

- long-term period (1 July 1997–30 June 2015);
- the historical period (1 January 1997–31 December 2000), incorporating the period when IIAS data were collected;
- the pre-Basslink period (1 January 2001–31 December 2005), when pre-Basslink data were collected;
- the post-Basslink period (1 May 2006–30 April 2014) prior to the current year ; and
- 2014–15 financial year (1 July 2014–30 June 2015).

The annual discharge curve in 2014–15 was a similar shape to the post-Basslink curve. The duration of high flows was lower relative to long-term, historical and all previous post-Basslink years, while lower discharges accounted for a relatively high proportion of flows.

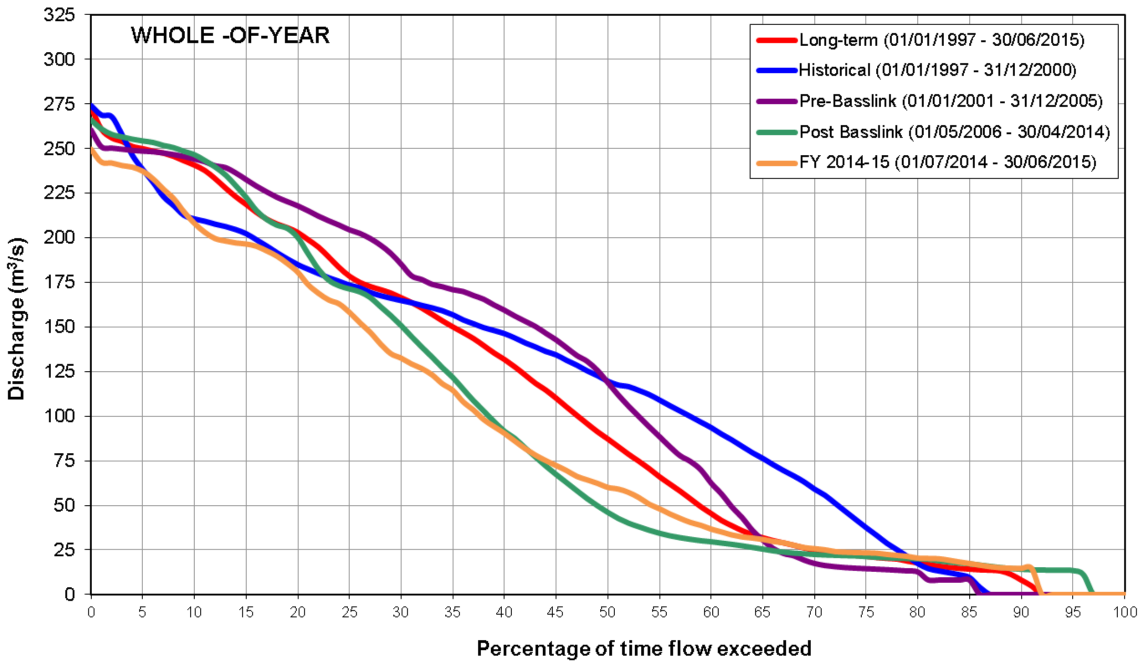

Figure 2-10: Duration curves for discharge from the power station using annual data for selected periods.

The 2014–15 winter discharge flow duration curve (Figure 2-11) was markedly different to the annual discharge curve and to all comparative curves. It is characterised by the “bump” in the mid-high range flow range (100-200 m^3s^{-1}) that was due to the high flows in July to September 2014 and June 2015.

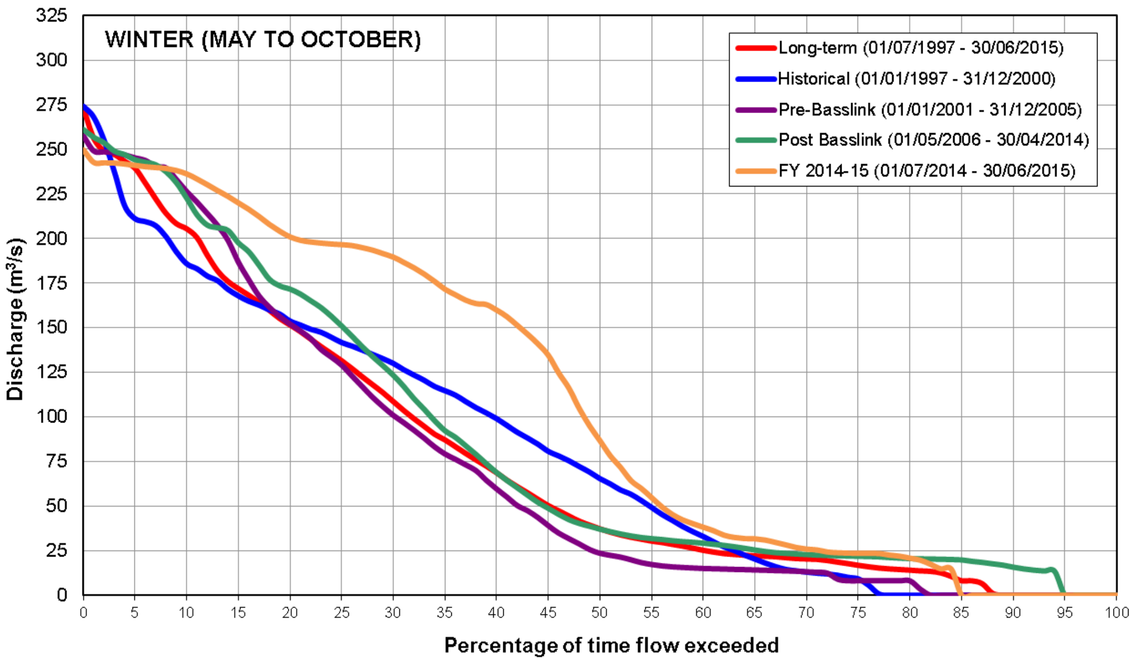

Figure 2-11: Duration curves for discharge from the Gordon Power Station using winter data (for the months of May to October inclusive) for selected periods.

The 2014–15 summer discharge flow duration curve (Figure 2-12) was also a different shape to that of the annual duration curve, and all of the comparative duration curves. The summer of 2014-15 had very few periods of high flow, but a much greater proportion of flows that were found in the middle and lower flow ranges.

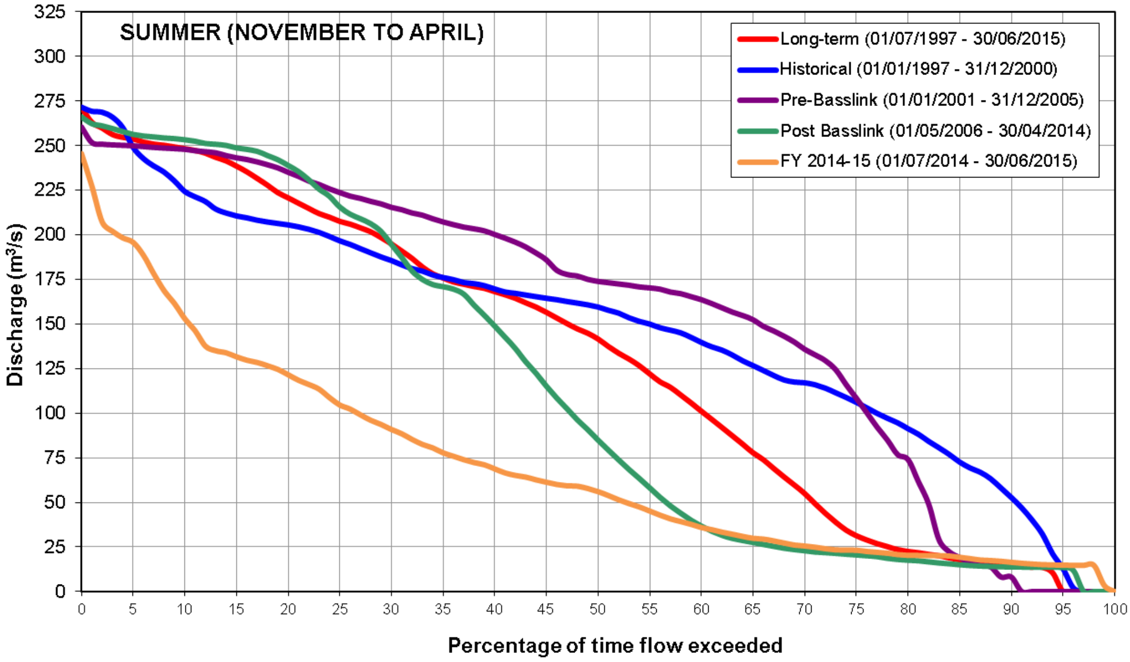

Figure 2-12: Duration curves for discharge from the Gordon Power Station using summer data (for the months of November to April inclusive) for selected periods.

Annual flow duration curves for each post-Basslink year are represented in Figure 2-13 to compare the reporting year to each of the previous post-Basslink monitoring years. As the post-Basslink period began on 1 May 2006, the annual periods for each of the post-Basslink duration curves are from May to April. Hence, the curve for 2014–15 differs slightly from the annual curve in Figure 2-10 as it represents a 12-month period that is offset by two months. Compared to other years, 2014–15 had a flow duration that is most similar to the “average” duration curve for the post-Basslink period.

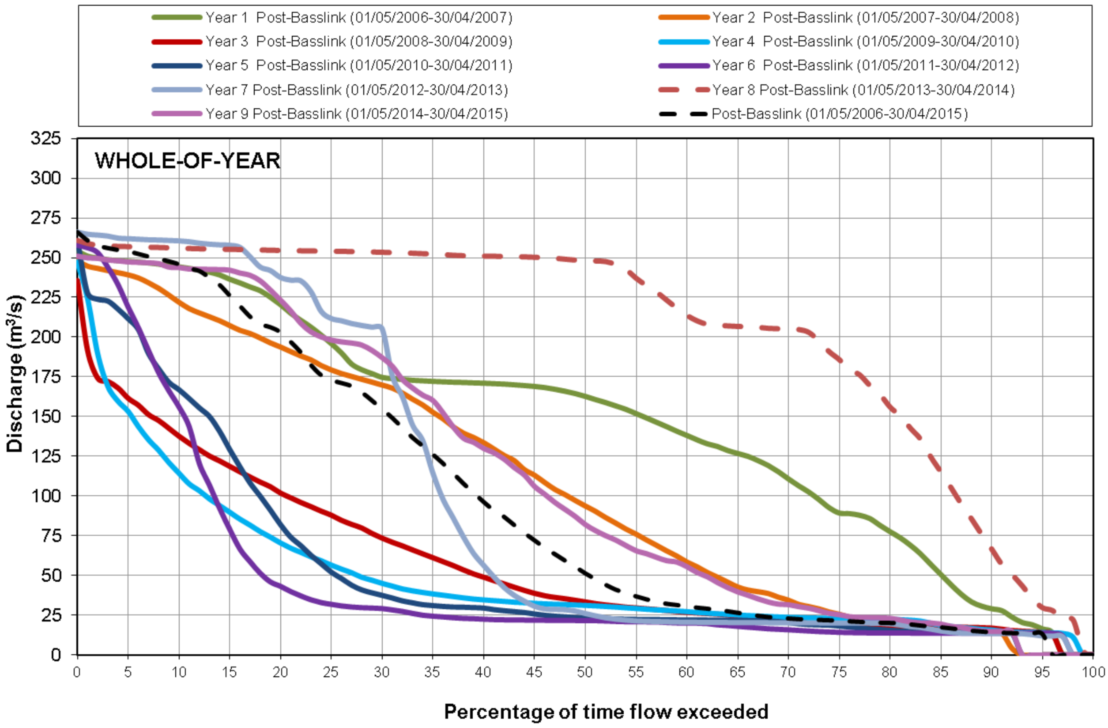

Figure 2-13: Annual duration curves for discharge from the Gordon Power Station for the nine years post-Basslink.

2.5.3.5 *Peaking hydrological triggers*

Time series of peaking event triggers are presented in Figure 2-14 and Figure 2-15. Peaking event exceedances in 2014-15 remained well below both of the triggers for the majority of the year. With increased peaking in April-June 2015, the 35-100 m^3s^{-1} trigger was exceeded in late June 2015. This is a trigger for monitoring to be undertaken in the following year (March 2016).

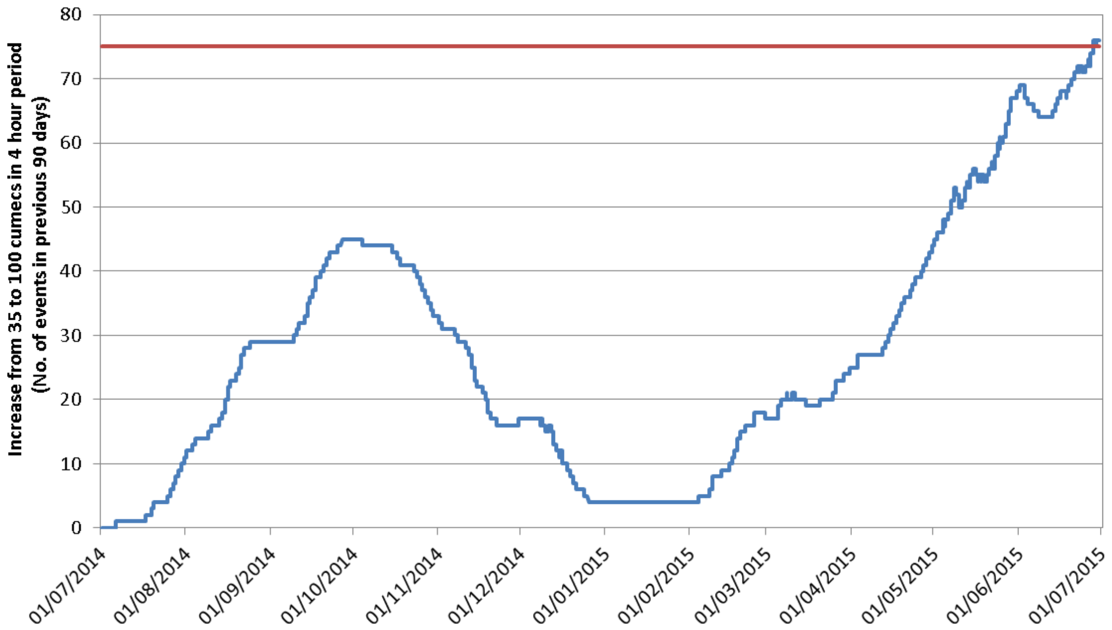

Figure 2-14: Time series of flow increases from 35 to 100 m^3s^{-1} in a four hour period, counted over the previous 90 days. Trigger value marked by red line.

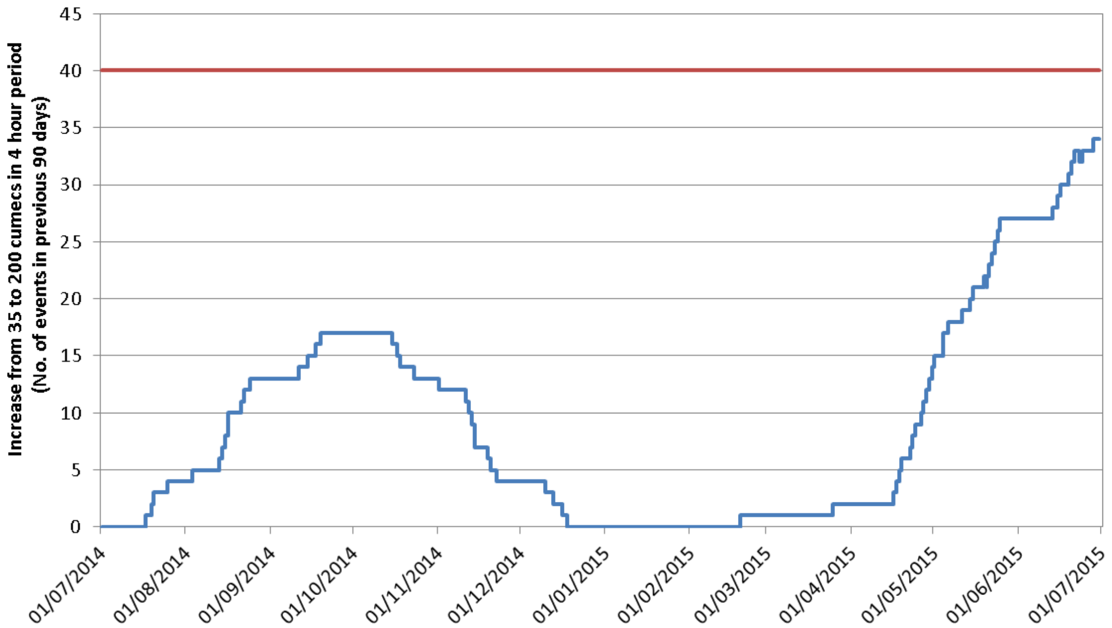

Figure 2-15: Time series of flow increases from 35 to 200 m^3s^{-1} in a four hour period, counted over the previous 90 days. Trigger value marked by red line.

2.5.3.6 Compliance with the ramp-down rule

In 2014-15, full compliance with the ramp-down rule was achieved. During the monitoring period (July 2014–June 2015) the ramp-down rule was required to be applied for 1584 hours (i.e. while the bank water level was >2.75 m and the power station discharge was >150 m^3s^{-1}). The control system was correctly set for all of those periods, resulting in complete compliance.

2.5.3.7 Evaluation of rate of change in generation

While the control system was automatically set to reduce generation at a rate of 1 MW per minute, when the modelled saturation and flow conditions were exceeded, there were occasions when the rate of generation reduction exceeded this rate.

Of the 1584 hours where ramping was required during flow reductions, those that exceeded 1 MW per minute occurred on 46 separate events (Appendix B), and totalled a little less than 8 hours (0.51% of time that the ramp-down rule was applied). Of these events, the majority (85% or 39 events) had a maximum reduction rate that was less than 1.1 MW per minute. The exceedances of 1 MW per minute occurred as a result of over-riding causes that were beyond operator control, and are not considered to be non-conformances. There were two principal reasons for the exceedences of the target reduction rate of 1 MW per minute:

- **Frequency excursions in the NEM:** can prompt a machine governor response. Common causes of such excursions include Basslink reversal, customer load reductions, and major changes in plant output anywhere in the NEM. This is a local governor response outside the 1 MW per minute control. In such instances, the power station is being used to stabilise the frequency and voltage within the NEM. This governor response is an intrinsic aspect of the machine, and an essential aspect of maintaining a stable electrical system and is beyond the control of the operators; and
- **Machine trips (sudden, automatically triggered shutdowns):** These can be triggered by fault detection at the machine or by a power system network event that will automatically trip the machine. These trips over-ride other intended operation and are beyond operator control.

The greatest exceedances of the 1 MW per minute reduction target were seen during events 1 (1 Jul 2014 – 1.77 MW/min) and 10 (22 Jul 2014 – 1.59 MW/min) (Appendix B). These large exceedences occurred as a result of simultaneous machine protection trips. The first of these (1 Jul 2014) occurred due to a protection trip on machine 2 due to a Basslink trip fault, while the second was due to a protection trip on machine 3 due to an operating system failure. Both of these events were beyond the control of operators.

2.5.3.8 Performance of the bank saturation model

As there are no further observational data, following the decommissioning of the piezometers at site 71, this will be the final assessment of the performance of the bank saturation model.

The bank saturation model provides estimates of the water level in the river banks to determine when the trigger level of 2.75 m was exceeded (Figure 2-16). Once the modelled level is exceeded, it is a requirement that the ramp-down rule is applied.

The analysis of 30 minute aggregated data over the complete period for which data was collected (44,514 observations from 1 April 2012 to 16 October 2014) indicated that the modelled data provided 1,225 false negatives (4.6 % of observed positives). This means the actual water level was greater than the trigger level of 2.75 m, while the model indicated that it was less than the trigger level. The ramp-down rule would not have been applied based on these modelled water levels.

This level of false negatives (i.e. 4.6%) has been a feature of the model, which has tended to underestimate the water level in the vicinity of the 2.75 m trigger. Attempts to improve the model in 2013-14, provided little improvement (Hydro Tasmania 2014) in the predictive capacity of the model. Given its limitations, the model has been operating within expectations and will continue to be utilised as a condition for the application of the ramp-down rule.

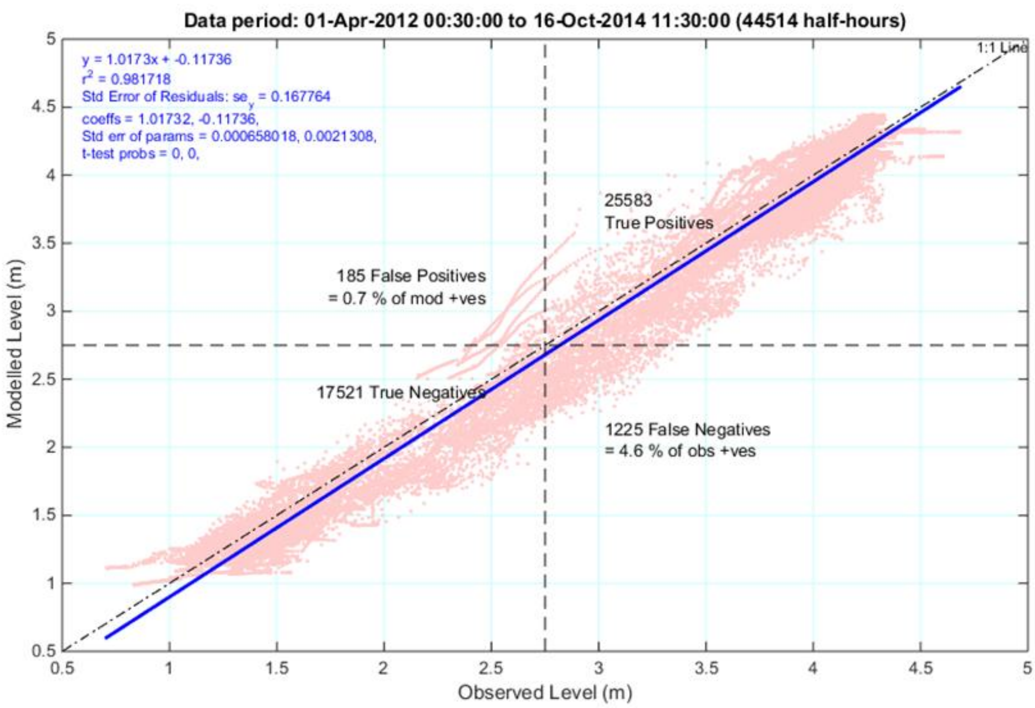

Figure 2-16: Observed versus modelled water levels for period 1 April 2012 to 16 October 2014 based on 30 minute aggregated data.

2.5.4 Gordon above Denison (site 65—environmental flow compliance site)

Site 65 is located in the Gordon River downstream of the power station, approximately 2 km upstream of the Denison confluence. This site monitors the minimum environmental flow required under the Special Water Licence Agreement.

2.5.4.1 Flow

Figure 2-17 shows the flow recorded at site 65 for 2014–5 and indicates close concordance with power station discharge to which peak values (the result of high flows from tributary streams, such as the Albert and Orange Rivers) are added.

Notable high tributary inflows were seen in July 2014, mid-May 2015 and June 2015. The significant departure of the hydrograph from that of the Gordon Power Station discharge is indicative of these tributary inflows from such rainfall events.

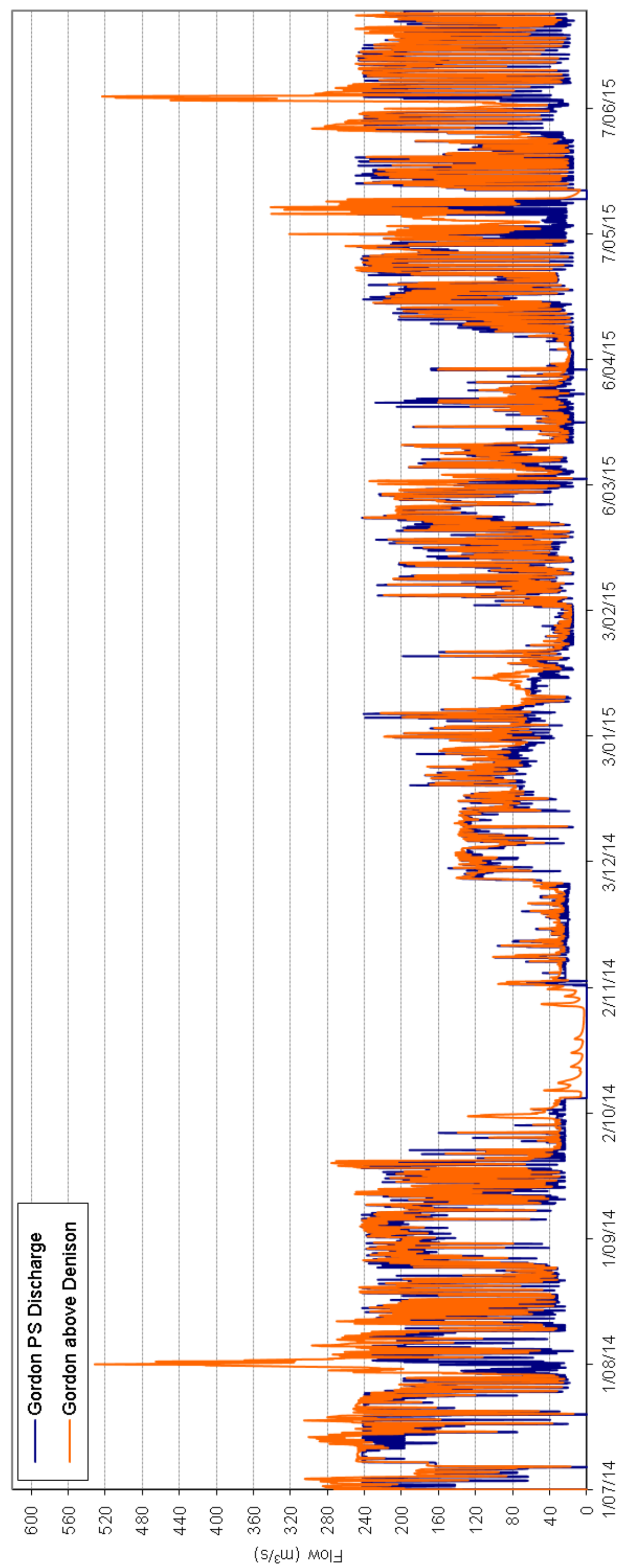

Figure 2-17: Flow recorded (hourly data) at site 65 (Gordon above Denison) showing full scale of flows, from July 2014 to June 2015.

2.5.4.2 *Median monthly flows*

The median monthly flow for site 65 (Gordon above Denison) is shown in Figure 2-18. Comparison with historic average (2003–15) patterns shows monthly median flows from July to September 2014 were well above average. October to December 2014 flows were near long term median values. The period from January to April was lower than the long term average, while May 2015 was near average and June 2015 substantially higher than the long term average. These followed a very similar pattern to those of the Gordon Power Station discharges.

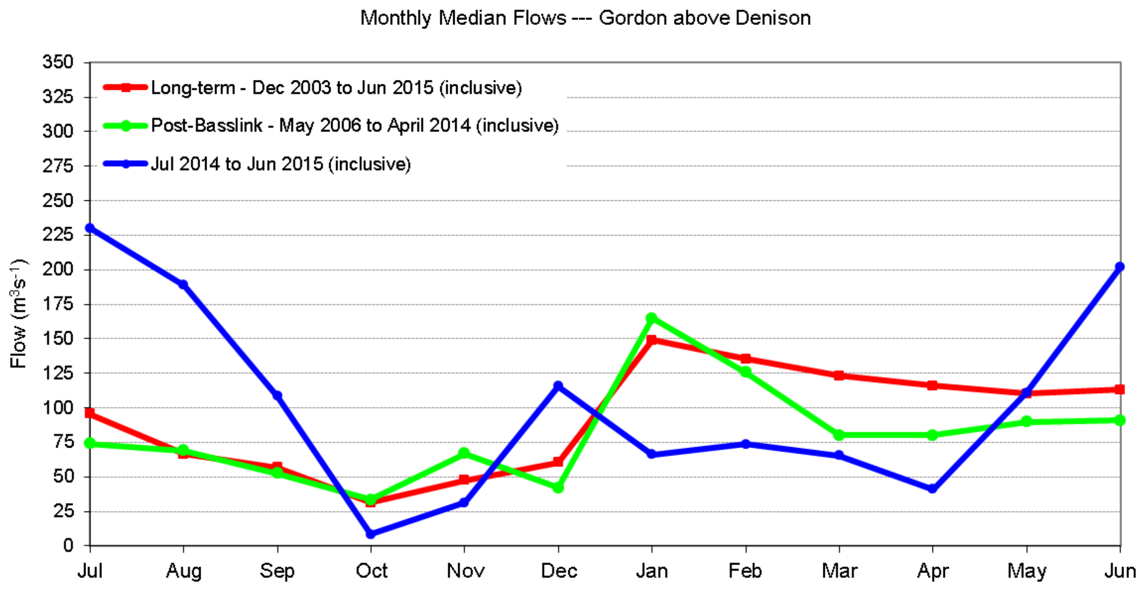

Figure 2-18: Median monthly flow at site 65 (Gordon above Denison) for 2014–15 compared with long-term median values and previous post-Basslink years.

2.5.4.3 Duration curves

The duration curve for site 65 is shown in Figure 2-19. Comparison of the 2014-15 duration curve with the long-term curve shows a very similar distribution of flows. There are no remarkable features of the duration curve in 2014-15.

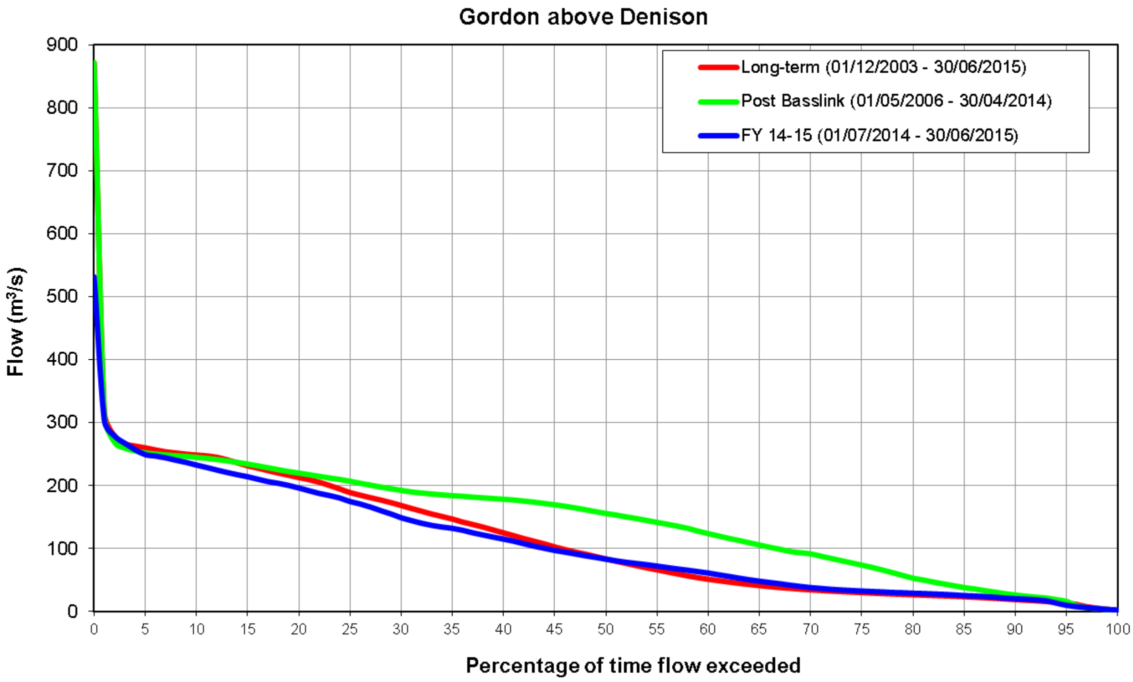

Figure 2-19: Flow duration curve for Gordon above Denison for 2014–15 compared with long-term and previous post-Basslink years.

2.5.4.4 Environmental flow compliance

For the period from December to May the minimum environmental flow required is 10 m^3s^{-1}, and for the period from June to November the minimum environmental flow required is 20 m^3s^{-1}.

An analysis of hourly flows at site 65 (Figure 2-20) shows that during the winter periods (July–November 2014 and June 2015) and the summer period (December 2014–May 2015), flow requirements were met 100 % of the time. Note that times of shutdown of the Gordon Power Station due to maintenance, AEMO conformance testing, and/or monitoring have been excluded from the analysis.

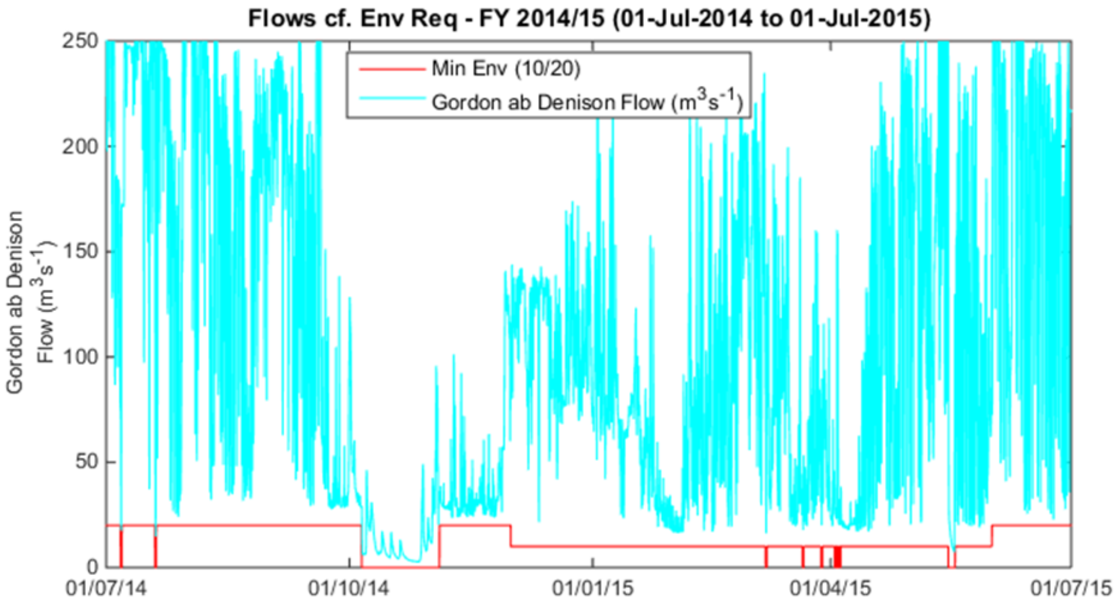

Figure 2-20: Flow recorded (hourly data) at site 65 (Gordon above Denison), from July 2014 to June 2015, and analysis of non-conforming flows.

2.5.4.5 High flow hydrological triggers

Flows at the compliance site exceeded the high flow hydrological triggers at the end of the last reporting period (from February 2014) and into the early part of July 2014 during the current reporting period. Subsequent to this, the proportion of high flows declined and remained well below the trigger levels from December 2014 through until June 2015. This exceedance of the high flow hydrological triggers was the cause for undertaking the geomorphology and macroinvertebrate monitoring in October 2014, the results of which are presented in this report (Chapter 3 and Chapter 4).

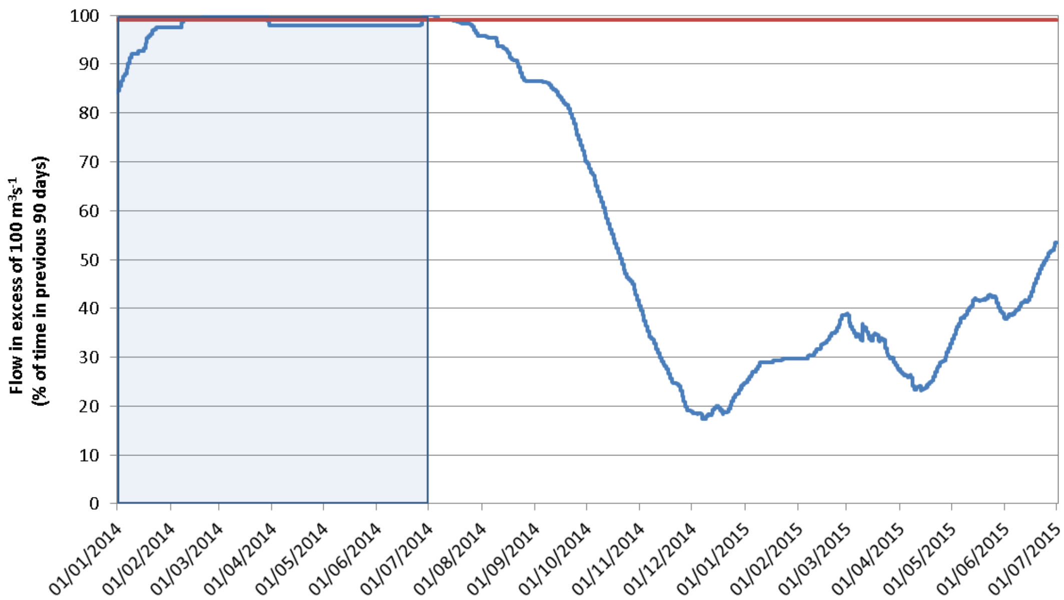

Figure 2-21: Time series (January 2014 – July 2015) of percentage of time in previous 90 days in excess of 100 m^3s^{-1}. Trigger value (99%) marked by red line. Previous reporting period is indicated by blue shading.

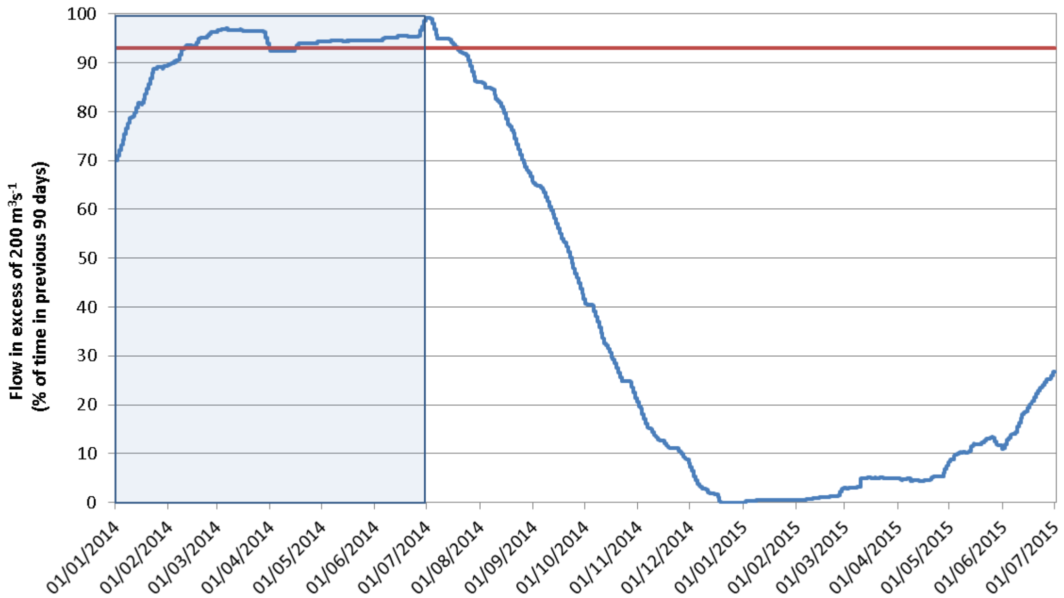

Figure 2-22: Time series of percentage of time in previous 90 days in excess of 200 m^3s^{-1}. Trigger value (93%) marked by red line. Previous reporting period is indicated by blue shading.

2.5.5 Gordon above Franklin (site 44)

The Gordon above Franklin site (site 44) is the furthest downstream monitoring site on the Gordon River. Power station discharges travel 33 km down the Gordon River before passing the gauge at site 44. The measured flow at this point is a combination of the power station discharge as well as the input from a number of significant tributaries, including the Albert, Orange, Denison, Maxwell, Olga and Sprent rivers. The Franklin River joins the Gordon downstream of site 44 and therefore is not included in the gauged data. Data from site 44 provides an indication of the influence of tributary streams and flow attenuation of the power station discharge on hydrology of the lower reaches of the river.

2.5.5.1 Flow

Figure 2-23 shows the hourly flows at site 44 for 2014–15 compared with discharge from the Gordon Power Station.

The flow rating at this site is based on only a small number of gaugings undertaken during monitoring periods. Of these, few gaugings have been taken at high flows, and it is acknowledged that the flow estimation, particularly at higher flows, is an under-estimate. In 2014–15, power station discharge continued to be a major flow component at site 44. However, there were some substantial divergences in hydrographs on a number of occasions where tributary flows (i.e. Denison River) provided a major proportion of the flow. High tributary flows were most common in July-August 2014. Other periods where significant tributary contributions occurred were in May 2015 and June 2015. The maximum flow of 964 m^3s^{-1} for the year occurred on 1 August 2014.

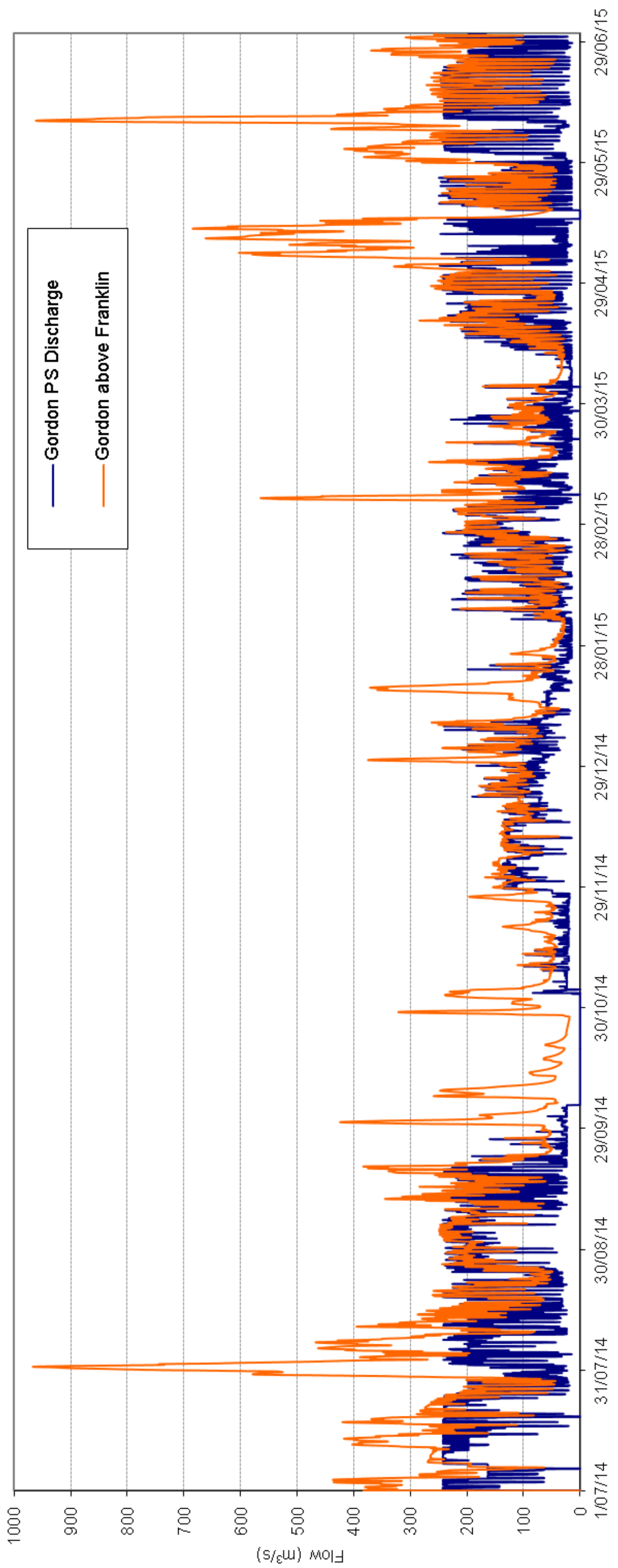

Figure 2-23: Flow recorded (hourly data) at site 44 (Gordon above Franklin) and Gordon Power Station discharge derived from the simplified three-dimensional rating during 2014–15. Median monthly flows.

2.5.5.2 Median monthly flows

Figure 2-24 shows the median monthly flow for the data at site 44 over the 2014–15 year, compared with the long-term post-dam (since January 1978) and post-Basslink patterns. Monthly median values in the monitoring year had similar patterns to both long term and post-Basslink periods.

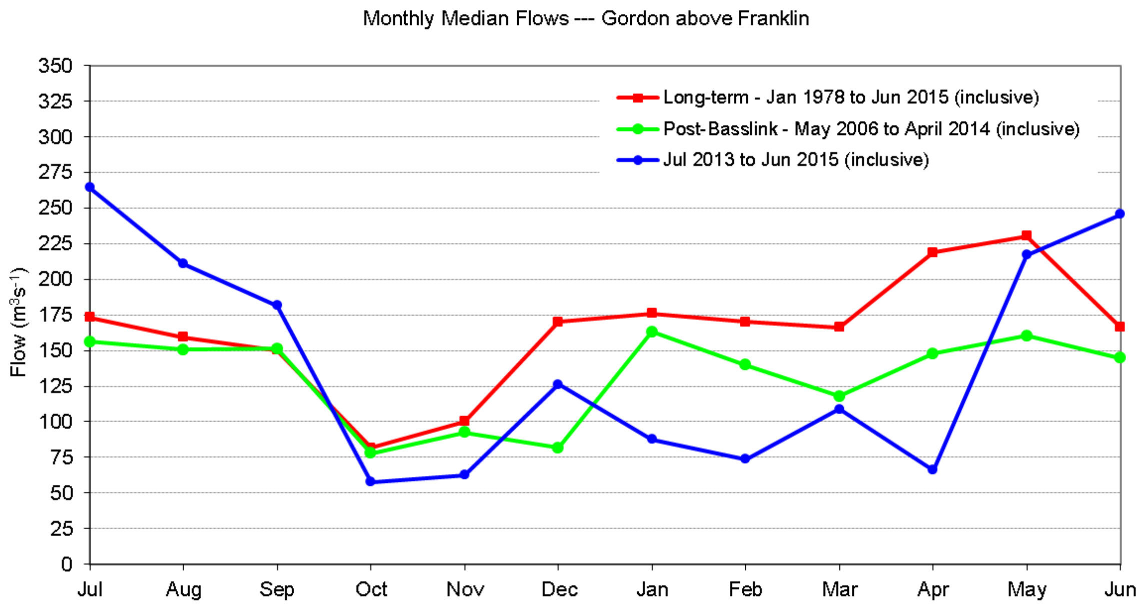

Figure 2-24: Median monthly flow at site 44 (Gordon above Franklin) for 2014–15 compared with long-term median values and previous post-Basslink years.

2.5.5.3 Duration curves

The duration curve for site 44 is shown in Figure 2-25. Comparison with the long-term curve is indicative of the similar distribution, though generally lower flows to those of the long term record.

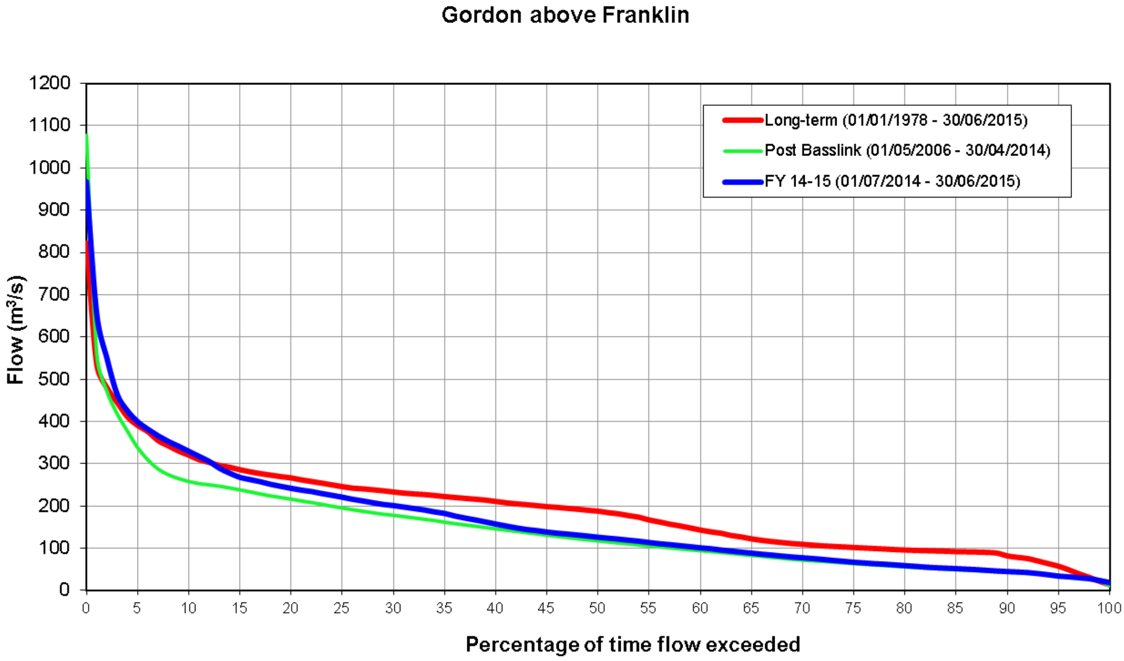

Figure 2-25: Flow duration curve for Gordon above Franklin (Site 44) for 2014–15 compared with long-term and previous post-Basslink years.

2.6 Conclusions

Discharges from Gordon Power Station were higher than the long term averages in July-September 2014 and July 2015, and lower in most other months. The months with higher discharges were associated with Basslink exports.

The operation of the ramp-down rule continued to be applied successfully in 2014-15. All ramping was consistent with the water licence requirements, as the system for controlling the rate of generation reduction was automatically activated under all trigger conditions (>2.75 m modelled bank level, >150 m^3s^{-1} discharge). The bank saturation regression model performed within expectations, modelling water level at the piezometer site.

The minimum environmental flow was achieved 100 % of the time both in summer and winter.

Hydrological triggers, to determine if monitoring is required in addition to biennial monitoring, were exceeded during 2013-14 and 2014-15. Monitoring was undertaken in October 2014 due to the exceedence of the high flow triggers (>100 m^3s^{-1} for >99% time in previous 90 days; >200 m^3s^{-1} for >99% time in previous 90 days) in 2013-14. In addition, one of the two peaking triggers was exceeded (35-100 m^3s^{-1} peaking trigger) late in June 2015. This exceedence triggers the requirement for a monitoring event, which coincides with the normal biennial monitoring to take place in March 2016.

3 Fluvial geomorphology

3.1 Introduction

This chapter summarises the October 2014 monitoring results and relates the findings to the current understanding of geomorphic processes in the middle Gordon River.

The aims of geomorphology monitoring in the Gordon River include:

- to document fluvial geomorphological processes and changes in the middle Gordon River between the power station tailrace and Sunshine Gorge (upstream of the confluence with the Olga River);
- to relate these changes to power station operations, including the ramp-down rule or other factors wherever possible; and
- to compare results with previous results to enhance the present understanding of the interaction between flow components and fluvial geomorphic response.

Twice yearly fluvial geomorphic monitoring was conducted in the middle Gordon River from October 2001 to 2014. Under a revised, on-going program, monitoring will continue at a reduced number of the geomorphic erosion pin and photo monitoring sites every 1-2 years, depending on the power station discharge regime (i.e. status of hydrological triggers).

The main aim of the on-going monitoring program is to use the results to continue to validate the conceptual model and to ascertain if and how the rates and trends, tracked by the monitoring program, are changing.

Field work completed in October 2014 included the removal of erosion pin sites no longer included in the program, measurement and upgrade of the long-term monitoring sites, and photo monitoring.

3.2 Methods

Basslink geomorphology monitoring is described in detail in the first pre-Basslink fluvial geomorphology monitoring report (Koehnken and Locher, 2002) and the Basslink Baseline Report (Hydro Tasmania 2005a, 2005b) and these documents should be consulted for a detailed description and background material pertaining to the monitoring program. Descriptions of the zones, bank types and processes operating in the middle Gordon River are contained in the initial Basslink IIAS report (Koehnken et al. 2001) and the Basslink Baseline Report (Hydro Tasmania, 2005a, 2005b). A history of monitoring in the middle Gordon associated with the Basslink monitoring program is shown in Table 3-1.

The observations, erosion pin measurements and photo monitoring were completed by boat based teams.

The current sub-set of erosion pin and photo-monitoring sites (Figure 3-1 to Figure 3-5, Table 3-2) were selected for continued monitoring based on the following criteria:

- the sites selected reflect a range of geomorphic properties considered to be representative of the middle Gordon River and monitoring results have shown a clear relationship between power station operations and geomorphic processes at these sites;

- the banks of these sites reflects one of the recognised stages of 'bank progression' linked to power station operations (e.g. stabilised by tea tree, loss of tea tree, onset of seepage/scour processes depending on bank slope, reduction in slope of bank toe, increase in slope of bank face etc.);
- a long historic monitoring record and stability of erosion pins over time; and
- their accessibility.

Table 3-1: Summary of geomorphology monitoring activities in the middle Gordon River between 1999 and present. Derivation indicates that the data was used in the formulation of trigger values, 'test' indicates that the erosion pin results from that monitoring period have been compared with the trigger values.

Monitoring Type	Triggers: Derivation or Test	Season	Dates	Monitoring completed
Pre-Basslink	Initial investigations		11 December 1999 18 December 1999 4 March 2000 25 March 2000 22 July 2000 2 September 2000 4 August 2001	Investigations for IIAS: Field observations Erosion pin measurements Photo monitoring Scour chains Painted cobbles
Pre-Basslink	Derivation	Spring 2001	23 November 2001 9 December 2001	Field observations Erosion pin measurements
Pre-Basslink	Derivation	Autumn 2002	10 February 2002 9 March2002	Field observations Erosion pin measurements Photo monitoring
Pre-Basslink	Derivation	Spring 2002	5 October 2002 16 December 2002	Field observations Erosion pin measurements
Pre-Basslink	Derivation	Autumn 2003	29 March 2003	Field observations Erosion pin measurements Photo monitoring
Pre-Basslink	Derivation	Spring 2003	18 October 2003	Field observations Erosion pin measurements
Pre-Basslink	Derivation	Autumn 2004	6 March 2004	Field observations Erosion pin measurements Photo monitoring
Pre-Basslink	Derivation	Spring 2004	9 October 2004	Field observations Erosion pin measurements Bank profiling
Pre-Basslink	Derivation	Autumn 2005	2 April 2005	Field observations Erosion pin measurements Photo monitoring
Pre-Basslink	Derivation	Spring 2005	15 October 2005	Field observations Erosion pin measurements
Transition	Test	Autumn 2006	11 March 2006	Field observations Erosion pin measurements Photo monitoring
Post-Basslink	Test	Spring 2006	17 October 2006	Field observations Erosion pin measurements
Post-Basslink	Test	Autumn 2007	17 March 2007	Field observations Erosion pin measurements Photo monitoring
Post-Basslink	Test	Spring 2007	20 October 2007	Field observations Erosion pin measurements
Post-Basslink	N/A	Spring 2007	1 December 2007	Field observations

Monitoring Type	Triggers: Derivation or Test	Season	Dates	Monitoring completed
Post-Basslink	Test	Autumn 2008	1 March 2008	Field observations Erosion pin measurements Photo monitoring
Post-Basslink	Test	Spring 2008	17 -19 October 2008	Field observations Erosion pin measurements
Post-Basslink	Test	Autumn 2009	21-22 March 2009	Field observations Erosion pin measurements Photo monitoring
Post-Basslink	Test	Spring 2009	17 October 2009 (zones 3&4) & 31 October 2009 (zones 1,2,5)	Field observations Erosion pin measurements
Post Basslink	Test	Autumn 2010	12-14 March 2010	Field observations Erosion pin measurements Photo monitoring
Post-Basslink	Test	Spring 2010	19-20 October 2010	Field observations Erosion pin measurements Establishment of vegetation transects at subset of geomorphology monitoring sites in zones 2 – 4.
Ramp-rule investigations	No	Summer 2011	7-days in January and March 2011	Observations of ramp-downs and draw downs at varying levels of bank saturation associated with investigations to revise ramp-rule.
Post-Basslink	Test	Autumn 2011	26-27 February 2011	Field observations Erosion pin measurements Photo monitoring
Post-Basslink	Test	Spring 2011	5-6 November 2011	Field observations Erosion pin measurements Combined geomorph & vegetation monitoring
Post-Basslink	Test	Autumn 2012	25 -26 February 2012	Field observations Erosion pin measurements Photo monitoring
Interim monitoring	N/A	Spring 2012	6 October 2012	Field observations zones (1-4, limited in zone 5) Erosion pin measurements (zones 1-4 only)
Interim monitoring	N/A	Autumn 2013	17 March 2013	Field observations Erosion pin measurements Photo monitoring (zones 1-5)
Interim monitoring	N/A	Spring 2013	9 November 2013	Field observations Erosion pin measurements (zones 1-5)
Interim monitoring	N/A	Autumn 2014	29 March 2014	Field observations Erosion pin measurements Photo monitoring (zones 1-5)
On-going monitoring	N/A	Spring 2014	13-15 October 2014	Field observations Erosion pin measurements Photo monitoring (zones 1-4)

Table 3.1 continued

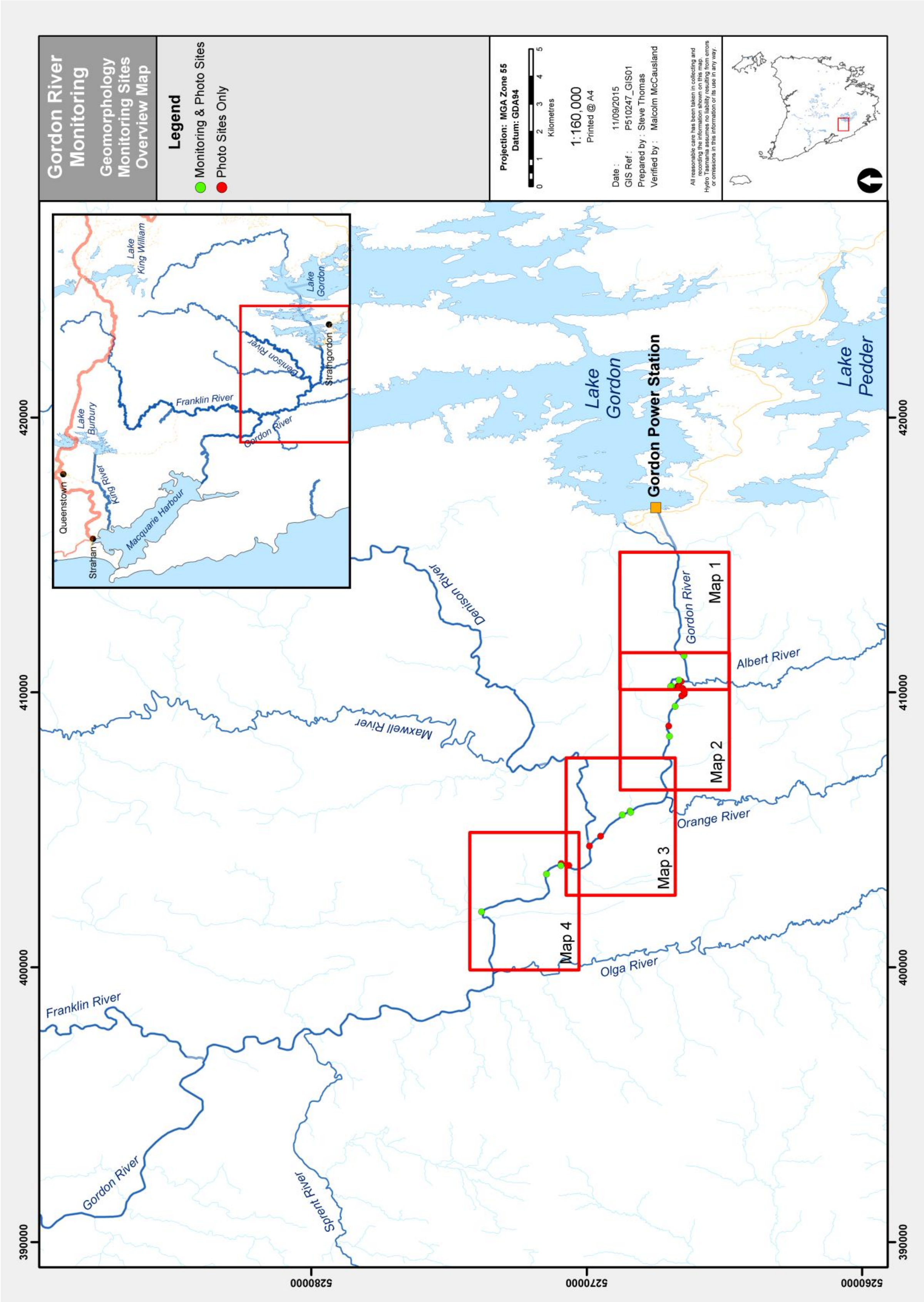

Figure 3-1: Overview of Gordon River geomorphology monitoring sites.

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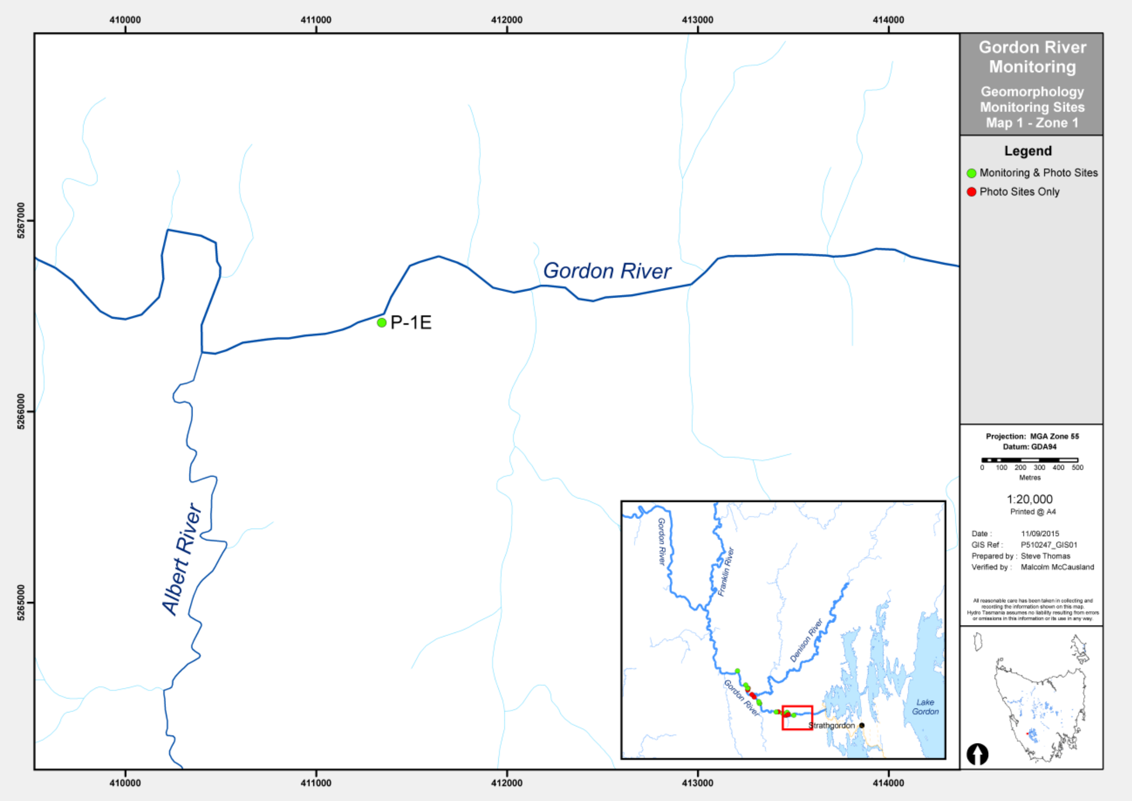


Figure 3-2: Gordon River geomorphology monitoring sites, zone 1.

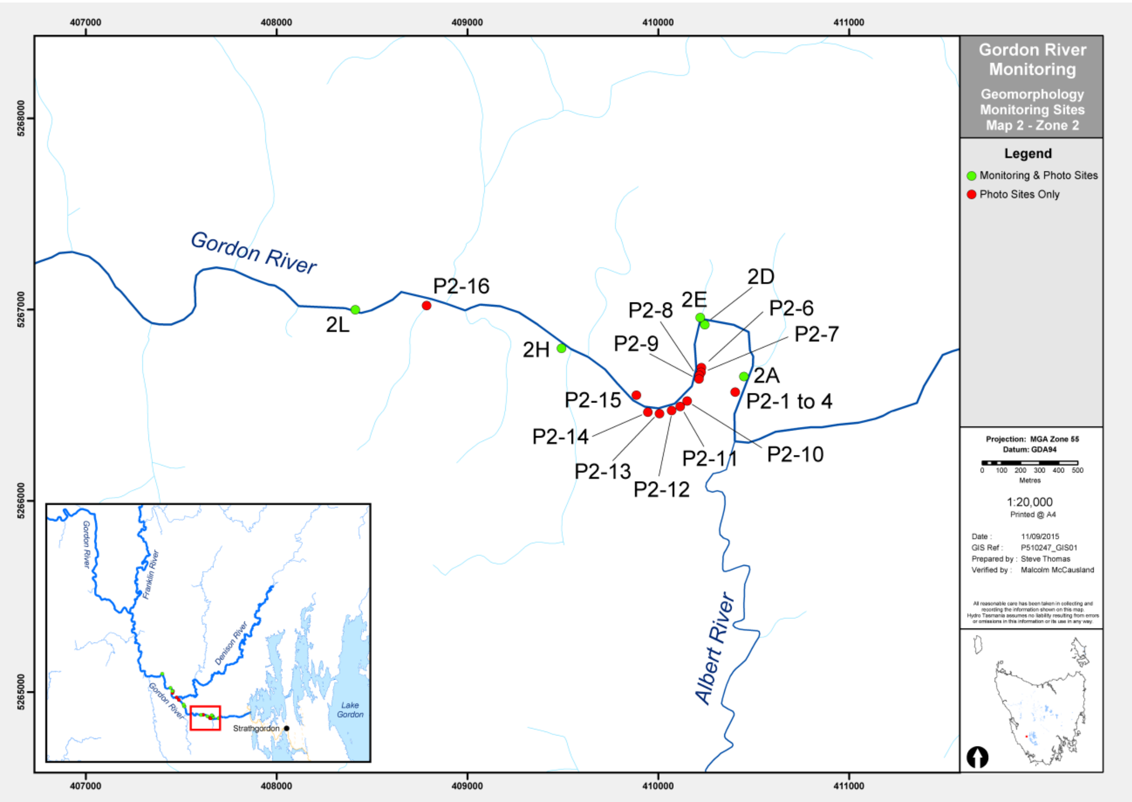


Figure 3-3: Gordon River geomorphology monitoring sites, zone 2.

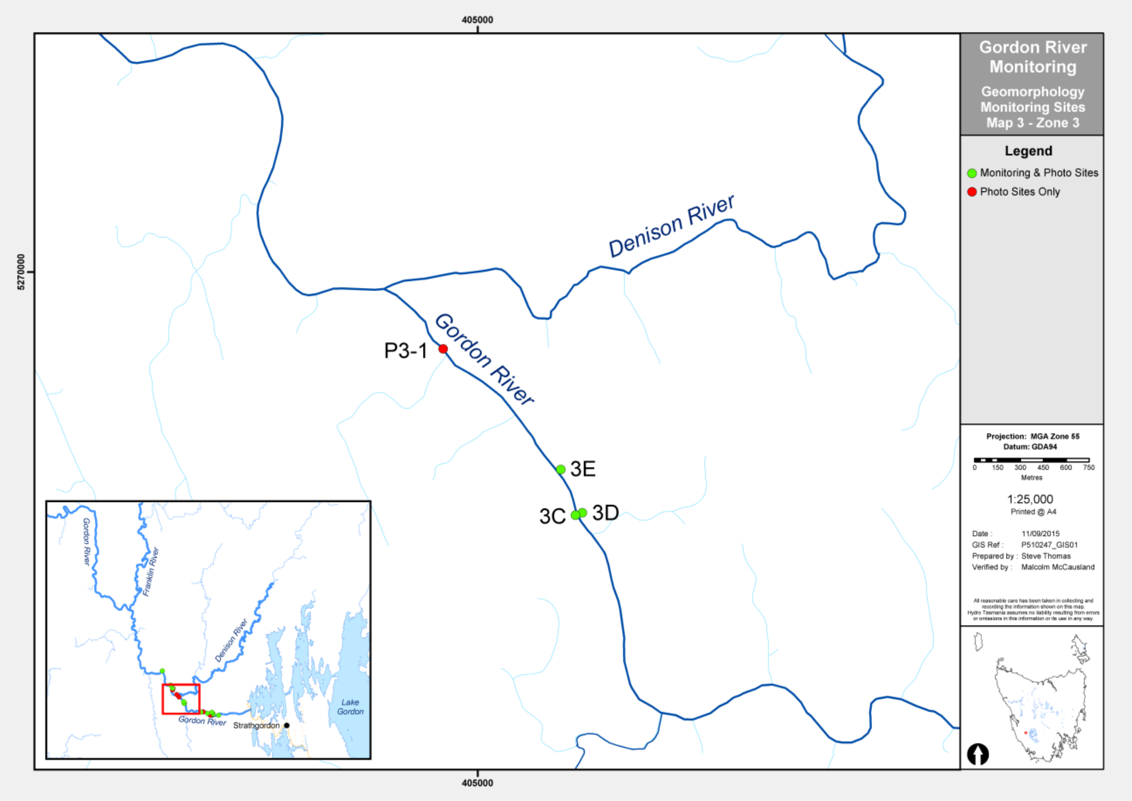


Figure 3-4: Gordon River geomorphology monitoring sites, zone 3.

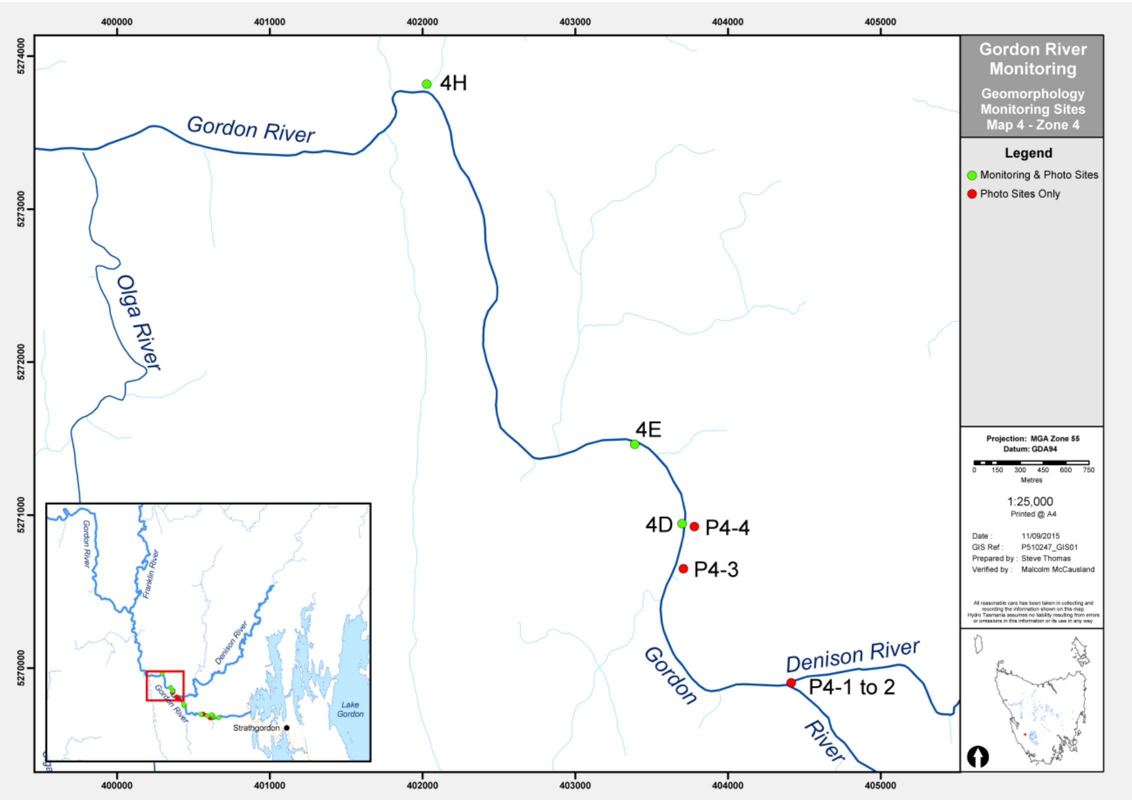


Figure 3-5: Gordon River geomorphology monitoring sites, zone 4.

Table 3-2: Number of monitoring sites and erosion pins in each geomorphology zone.

Zone	No. combined monitoring and photo sites	No. photo-only sites	No. erosion pins
Zone 1	1	0	13
Zone 2	5	16	36
Zone 3	3	1	22
Zone 4	3	4	18
Total	12	21	89

3.3 Monitoring in spring 2014

The spring 2014 geomorphology monitoring was undertaken from 13-15 October 2014. Erosion pin sites in zones 1 to 4 were either removed or upgraded. The activities completed are summarised in

Table 3-3. Water level in the Gordon River was relatively low, with only a few of the erosion pins located on bank toes partially submerged. Flow at the Gordon above Denison compliance site decreased from ~15 m^3s^{-1} to ~5 m^3s^{-1} over the monitoring period.

Pin 3C/55 in zone 3 was the only pin not located in October 2014, despite it having been located previously in March 2014. This pin had recorded ~ 300 mm of erosion in the March 2014 monitoring, and had probably been eroded out of the bank. The pin was not replaced.

Table 3-3: Summary of geomorphic monitoring activities completed in October 2014.

Date	Tasks
13 October 2014	• Removal of erosion pins from zone 1 • Measurement, re-tagging and upgrading of erosion pin site 1E
14 October 2014	• Removal of erosion pins from zone 2 • Measurement, re-tagging and upgrading of erosion pin sites 2A, 2D, 2E, 2H, 2L; • Photo monitoring in zone 2- • Removal of erosion pins from monitoring sites in zone 5
15 October 2014	• Removal of erosion pins from zones 3 & 4; • Measurement, re-tagging and upgrading of erosion pin sites 3C, 3D, 3E, 4D, 4E, 4H

3.4 Overview of hydrology, March 2014 – November 2014

A detailed discussion of the hydrology of the Gordon River during the 2014-15 monitoring year is presented in Chapter 2. The following short discussion highlights hydrologic characteristics of the monitoring year relevant to the geomorphology monitoring results.

Discharge from the Gordon Power Station between March 2014 and October 2014 is shown in Figure 3-6, and discharge from the station is compared to flow at the Gordon above Denison Compliance site and Gordon above Franklin gauging site in Figure 3-7. The hydrographs show the following features relevant to the geomorphic investigations:

- Discharge was high from the Gordon Power Station from March 2014 through mid-June 2014, with only a few periods of discharge <200 m^3s^{-1};
- During the winter of 2014, the discharge from the Gordon Power Station was characterised by high frequency flow events ranging from moderate to high volume;
- During the reporting period there were some high flow events in the Gordon River above the Franklin River (site 44) due to unregulated inflows, ranging from 500-1000 m^3s^{-1}. In general, the high flow events coincided with high power station discharge, except in July 2014 when the largest inflows coincided reduced discharge at the power station;
- There was a natural flow event in October 2014 (424 m^3s^{-1} at Gordon River above Franklin), which occurred immediately prior to the geomorphic monitoring campaign.

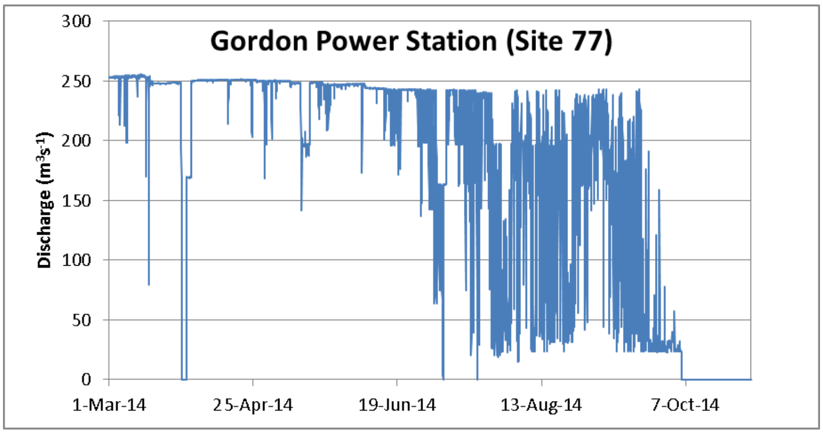


Figure 3-6: Hydrograph of discharge from the Gordon Power Station between March and October 2014.

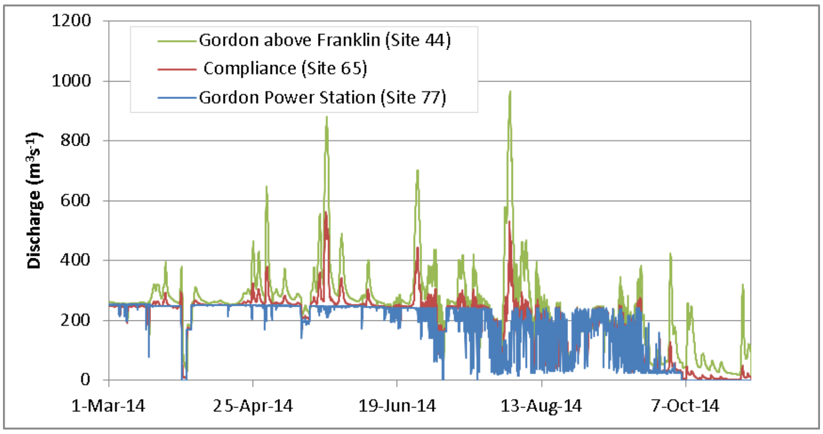


Figure 3-7: Flow at the Gordon Power Station, Gordon above Denison (Compliance site) and the Gordon above Franklin River sites between March and October 2014.

3.5 Monitoring results

3.5.1 Field observations: spring 2014

Field observations in spring 2014 included the following:

- A new sand bar was observed at the upstream end of zone 2 in the pool downstream of Abel Gorge (Figure 3-8). The bar is in the same location as an 'underwater sand bar' documented in the 1999 aerial photo analysis, but no bar has ever been observed during the Basslink monitoring or Interim monitoring field excursions. The bar was not evident in the 1974 aerial photo analysis of the river. The appearance of the bar is not related to water levels during sampling, as the spring 2014 river levels were not appreciably lower than during other monitoring periods.
- Changes to the shape of the 'Construction Bar' in zone 1 (Figure 3-8). The 'Construction Bar' was not present in the Gordon prior to the construction of the power station. The bar appears to have become more 'streamline' in shape over the past 10-years. Based on field observations, these changes have been most pronounced in the last 2 years, during the period of extended power station discharge. Changes to the construction bar are consistent with how other bars in the river responded to the initial increase in discharge associated with power station operation. It is likely that the bar is responding to the recent period of increased power station discharge.
- Scour and seepage features were present on banks, with seepage processes affecting bank toes and scour occurring on the bank faces (Figure 3-10). Seepage features included rilling, tension cracks, small scale sediment flows. Scour eroded root mats and the underlying sand;
- The high flow event, occurring during the week between the power station shutting down and monitoring was completed, resulted in the deposition of mud veneers on bank toes (Figure 3-11);
- The increased and prolonged discharge from the power station has affected vegetation in a variety of ways:
  - The plimsoll line appears to be increasing in height in zones 1 and 2 which is consistent with the increased level of water in the river (Figure 3-11);
  - Vegetation continues to be lost from backwaters and bank faces where plants had established during the years when power station usage was low (Figure 3-12);
  - There continues to be a loss of trees close to the edge of the river. It is unknown if tree loss is attributable to the extended inundation being experienced by the trees or increased water level in the river (Figure 3-13);
  - Loss of adventitious roots on tea tree (Figure 3-14). These roots were widespread and visually prominent during autumn 2014. The loss of the roots is likely attributable to desiccation following the reduction in power station usage in September 2014 accompanied by increased seasonal temperatures.
  - A field observation, not previously observed in the Gordon River, was the vivid white colour of the dolomite/limestone outcrops in zone 2. These outcrops are generally grey to black in colour, but in October 2014 there were many exposed surfaces which were white, clean and very smooth (Figure 3-15). The removal of the dark

mineral or biological coatings, is not significant with respect to the overall geomorphology of the study area. This minor change is most likely attributable to abrasion during the extended periods of inundation.

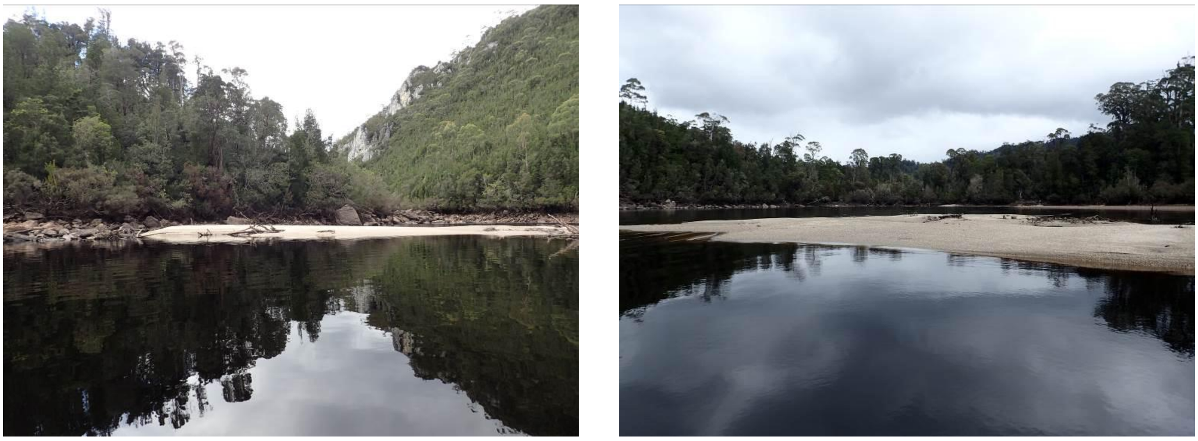


Figure 3-8: 'New' sand bar at upstream end of zone 2 with Abel Gorge in the background.

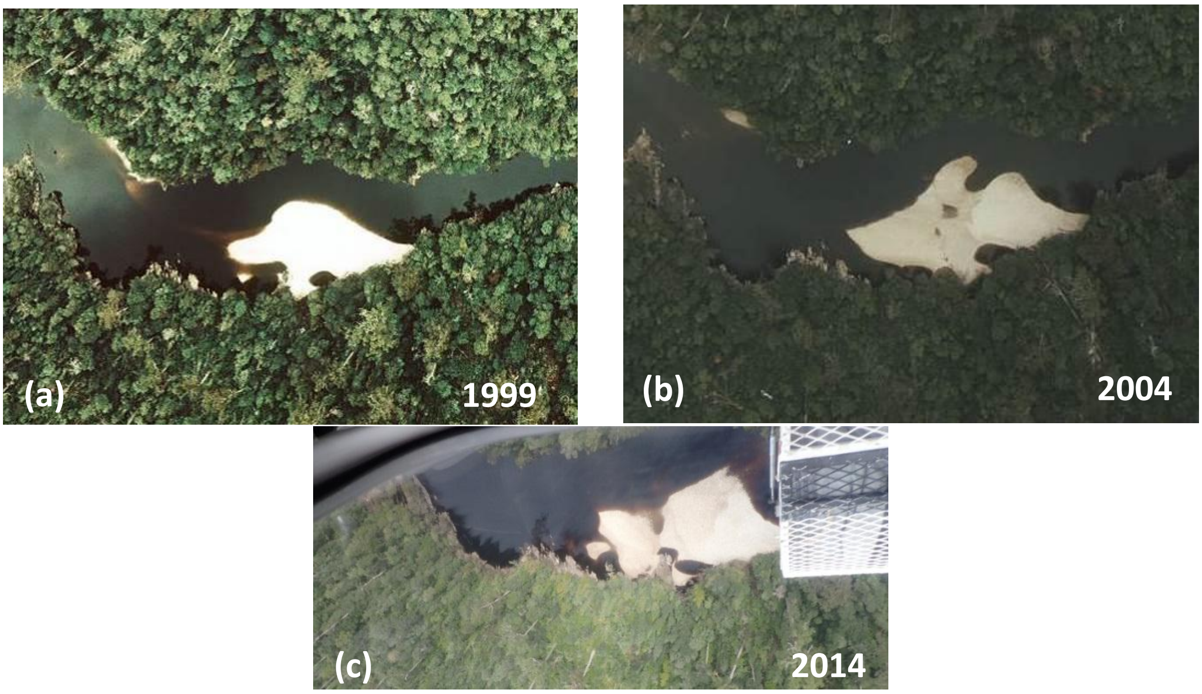


Figure 3-9: Comparison of 'Construction Bar' in zone 1 in (a) 1999, (b) 2004 and (c) 2014.

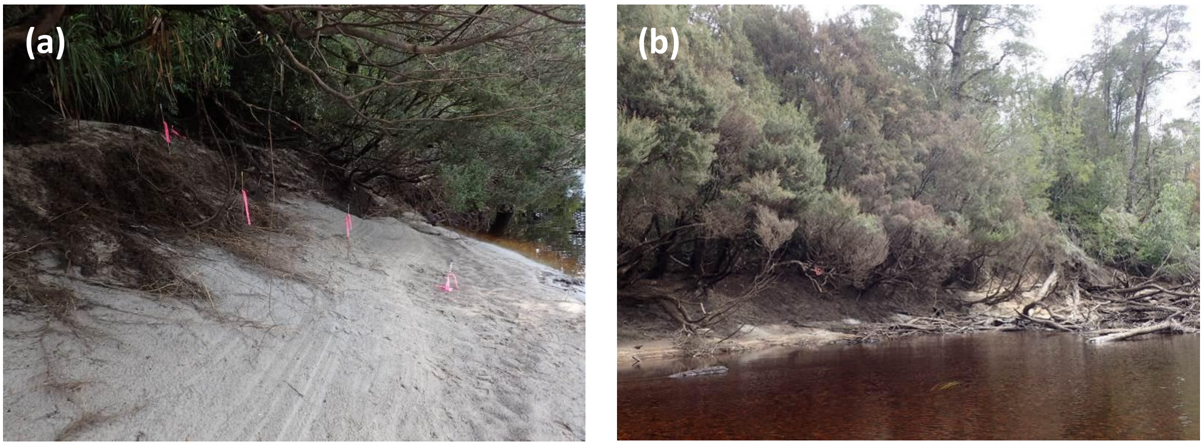


Figure 3-10: Scour and seepage features in zone 3. (a) Site 3E - scour on upper bank, seepage on lower bank; (b) site 3H - small sediment flows from under root mat.

Figure 3-11: Mud veneers on bank toes indicative of high flow event during power station shut-down. Increased browning and loss of vegetation associated with leading to increasing height of plimsoll line.

Figure 3-12: Backwater channel at erosion pin site 2A showing lack of vegetation.

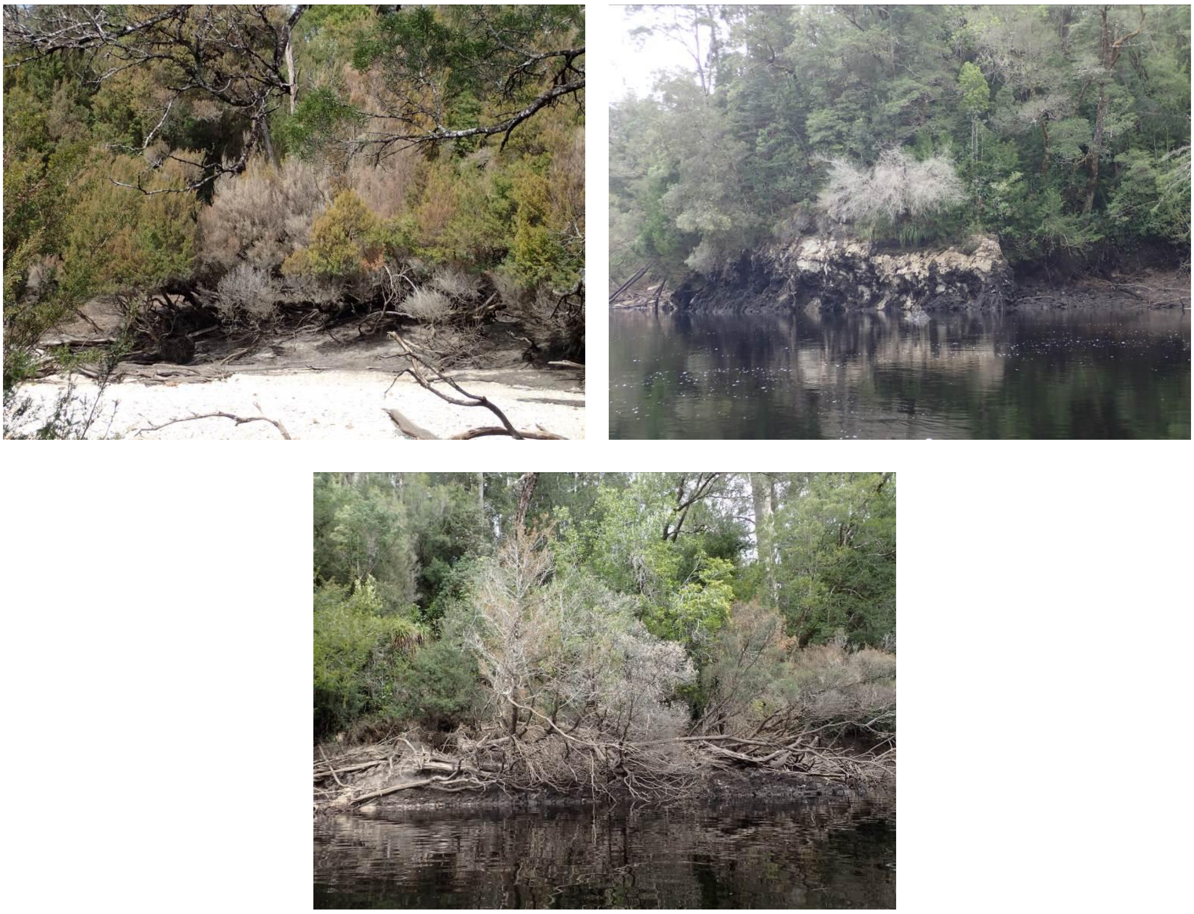


Figure 3-13: Examples of brown or dying vegetation adjacent to the river channel.

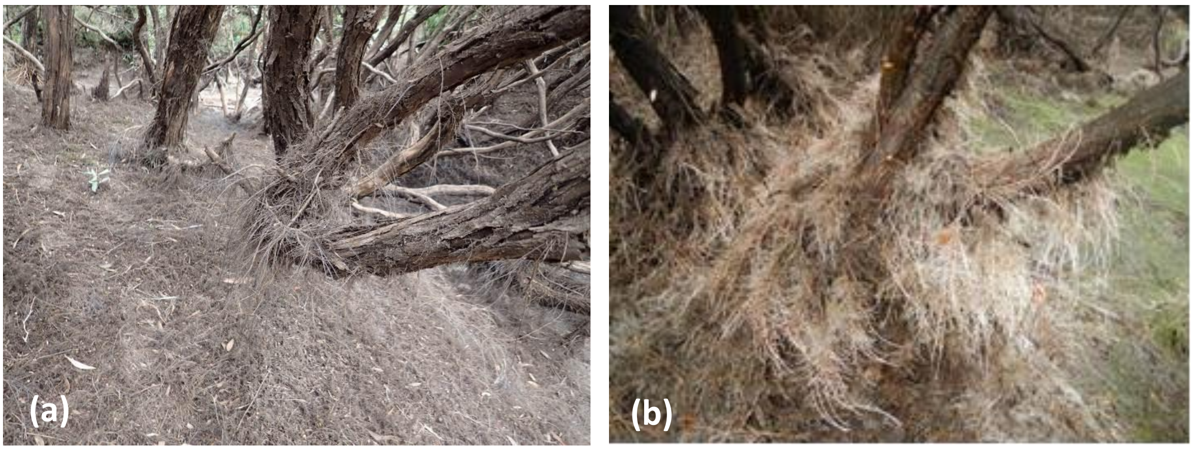


Figure 3-14: Dessicated adventitous roots on tea tree in (a) October 2014 compared to (b) March 2014.

Figure 3-15: The very white surface of dolomite outcrops in zone 2, possibly resulting from abrasion.

3.5.2 Erosion pin results

Erosion pin monitoring were collected from 12 sites in geomorphic zones 1 – 4. The results from spring 2014 are shown for each pin at each site along with the historic results from each site (Figure 3-16 to Figure 3-20). A short description of each site and brief interpretation of the recent results is contained in the following section.

Site 1E is located on an alluvial bank which is stabilised by tea tree and a root mat which is being lost through scour. Initially there were benches at discrete turbine levels present on the bank, but these are being removed as the bank reduces in slope through slow seepage processes (Figure 3-16). The reduction in slope is most pronounced on the lower bank (pins 1-5) (Figure 3-16). The spring 2014 results are consistent with previous result obtained during the period of extensive power station usage (Figure 3-16).

Site 2A is also located on a bank supporting tea tree. The bank separates the main channel from a back channel which is active when the power station is in use. Pins 1 – 4 and Pin 8 are on the river side, with pins 5 – 7 on the back channel side. The river side of the site shows low rates of change, while the back channel side shows the flattening of the bank at Pins 6 and 7s through seepage processes (Figure 3-17). The recent results suggest that the bank slumping in the back channel is beginning to affect Pin 5 as well.

Site 2D is located in an active reach of the river with respect to seepage erosion processes. The site has shown cycles of flattening of the bank toe (pin D4) and erosion of the upper bank, followed by erosion of the bank toe and flattening of the upper bank (Figure 3-17). The spring 2014 results predominantly show 'deposition' related to seepage processes with the exception of pin D6, which is located at the base of a break in slope on the bank, which shows erosion (Figure 3-17).

Site 2E is located on the opposite bank from site 2D and is also on a very active bank with respect to seepage erosion processes. The site has recorded a flattening of the bank toe and erosion of the bank face in the past, but recent results suggest scour is the predominant process (Figure 3-18). Pin E1 is located in a cavity on the bank, and its variability is partially attributable to difficulties associated with measuring.

Site 2H contains 2 parallel profiles of erosion pins. One set (Pins H1 – H3) is in a tea tree bank, and the other (H4 - H7) is immediately downstream in an area where the tea tree has been lost and the steep bank is prone to seepage processes. The erosion pin results have captured the movement of a large Huon Pine down slope, and the flattening of the seepage affected bank. Sand has been observed being washed out from the tea tree root-mat in recent years. The erosion pin results show the stability of the tea tree bank, and the flattening of the seepage affected bank (Figure 3-18). Pin H4 was lost under a Huon Pine tree as it moved downslope.

Site 2L is the most downstream site in zone 2, and is subjected to the largest water level fluctuations. The erosion pins have captured the removal of a muddy root mat through erosion and reduction in slope of the upper bank as 'benches' associated with turbine levels are removed. Pin L3 has recorded two cycles of erosion followed by deposition, with the recent high discharge period associated with a period of deposition (Figure 3-18). Pin L1 is located in a cavity upstream of the main site, and the results suggest there has been slumping of the bank over the past 6-months (Figure 3-18).

Sites 3C is located on the right bank in Zone 3 just upstream of the Compliance Site. This site is affected by inflows from the Orange River, and backwater effects from the Denison River. Site 3C has shown flattening of the bank toe, with little change to the remaining bank due to the presence of a thick root mat (Figure 3-19). Pin C1 is in a cavity and has been lost due to bank collapse. Pin 3C55, which was also located at approximately the 55 m^3s^{-1} flow level has also been lost most likely due to erosion (based on high level of erosion recorded in March 2014).

Site 3D is located on the left bank, opposite from site 3D upstream of the Compliance site. Pin D1 is in a cavity, Pin D4 is horizontal in the steep bank face, with the other pins on the sandy bank toe. The results show a flattening of the bank, with the bank toe (D3) recording erosion followed by deposition, and Pins D2 and D55 have recorded predominantly erosion (Figure 3-19).

Site 3E is located half way down zone 3, and is composed of a large sandy bank toe. The bank generally records erosion; however, high levels of deposition occur following large unregulated inflows. The form of the bank has changed from convex to concave over the past two years owing to erosion during the period of high power station discharge (Figure 3-19).

Site 4D is located mid-way down zone 4 on the left bank at the downstream end of a cobble bar. The toe of the bank is buttressed by a large log which has stabilised the bank toe, with Pin 3 (toe) showing small scale cycles of deposition and erosion. The upper bank is undergoing a reduction in slope through seepage processes. The period of high power station discharge has led to a decrease in slope in the mid bank (Pins D9 and D2) (Figure 3-20).

Site 4E is located on the left bank at an inside bend across from Kayak Cavern. This steep site has generally shown erosion due to scour, which has increased during the period of high power station discharge (Figure 3-20). This site was substantially altered during the natural flood event in August 2007.

Site 4H is located at the downstream end of zone 4, upstream of Sunshine gorge near the confluence of the Harrison and Smith Creeks with the Gordon River. This site has shown flattening of the upper bank, and cyclic erosion of the toe (Pins H4 and H5) (Figure 3-20). This site is also subject to the deposition of large woody debris.

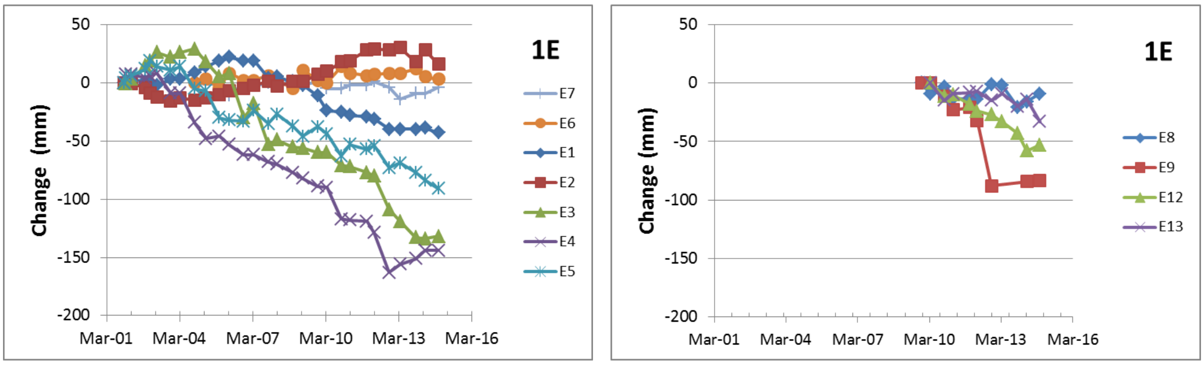


Figure 3-16: Erosion pin results for site 1E. Pins in graph on left form one profile down bank; pins in graph on right are duplicates. Legend shows approximate order of erosion pins from upslope to downslope.

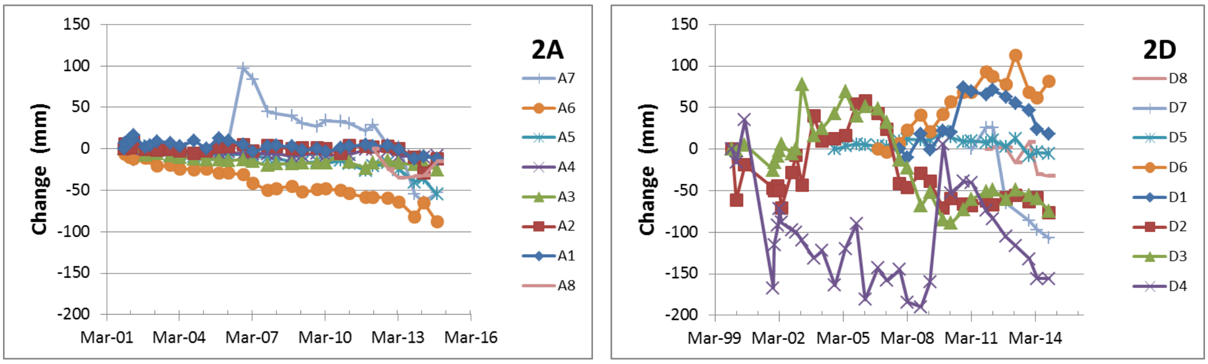


Figure 3-17: Erosion pin results for sites 2A and 2D. For site 2A, legend hows pins in order on bank from backwater to river side of the bank. For site 2D, legend shows approximate order of erosion pins from upslope to downslope.

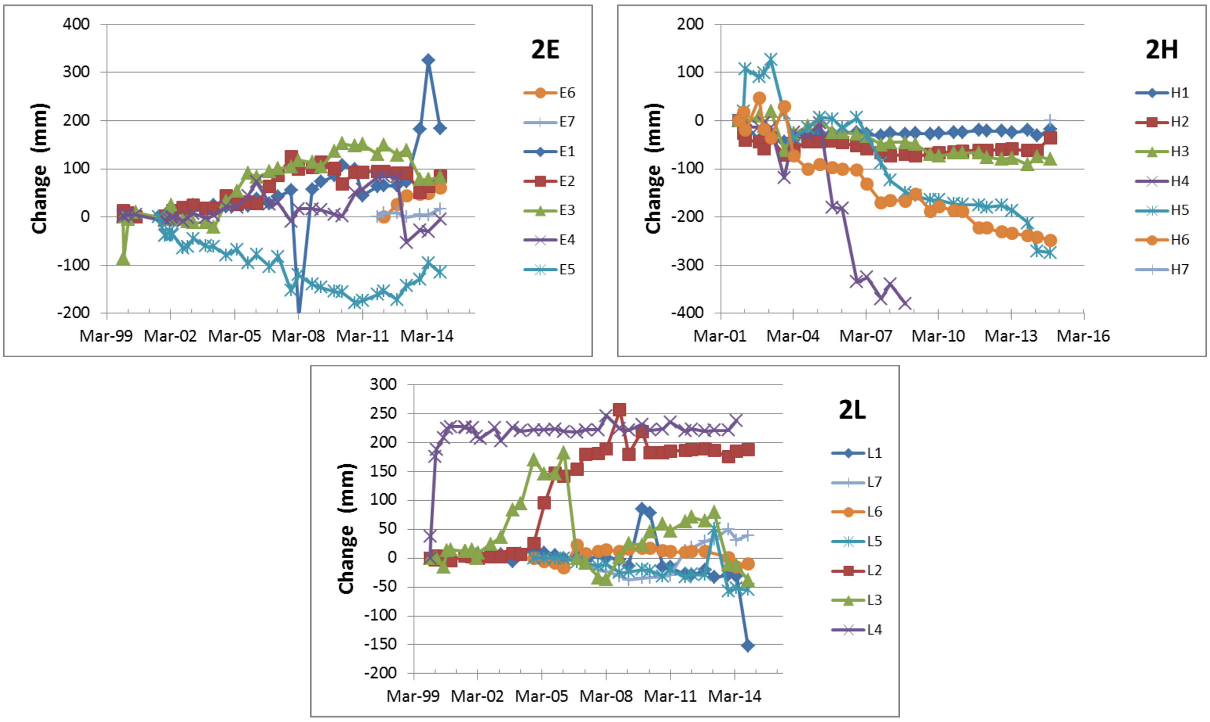


Figure 3-18: Erosion pin results for sites 2E, 2H and 2L. Legends for both sites show approximate order of erosion pins from upslope to downslope.

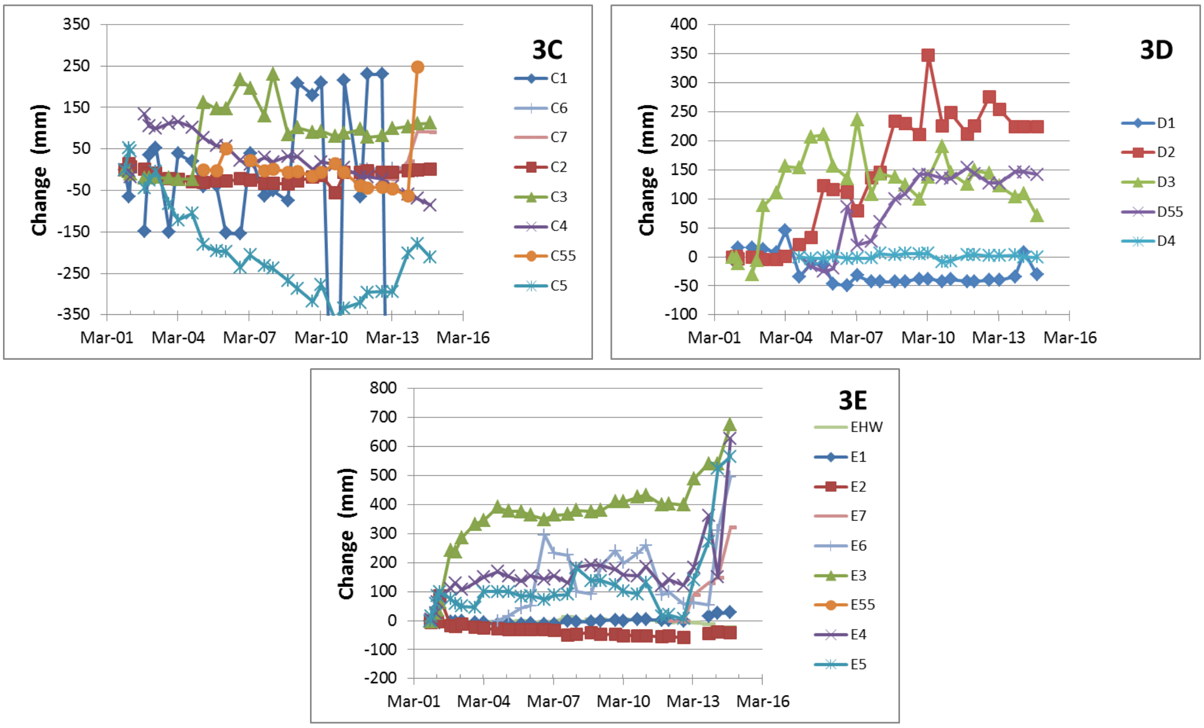


Figure 3-19: Erosion pin results for sits 3C, 3D and 3E. Legend shows approximate order of erosion pins from upslope to downslope.

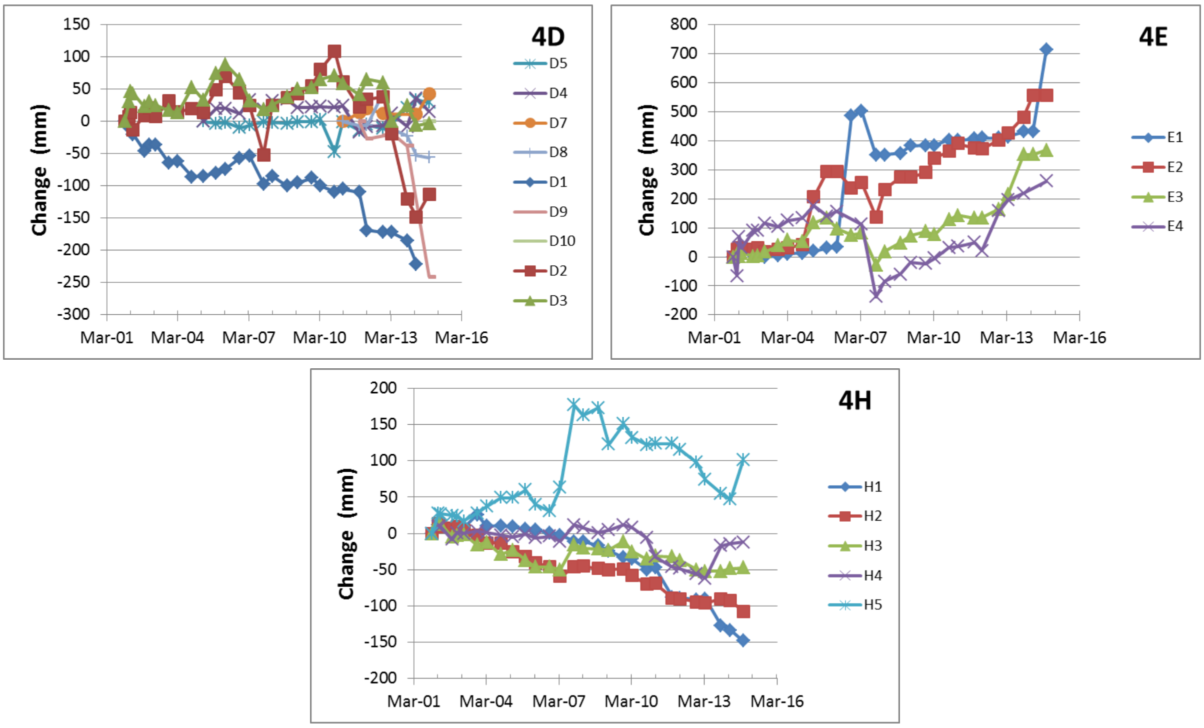


Figure 3-20: Erosion pin results for site 4D, 4E and 4H. Legend shows approximate order of erosion pins from upslope to downslope.

3.5.2.1 Erosion pin summary

In summary, the erosion pin results are consistent with the understanding of erosional processes operating in the middle Gordon River. Sites characterised by tea tree and associated root-mats exhibit more stability owing to the presence of the vegetation and associated root-mat. Under periods of high power station discharge, these sites are affected by scour of the root-mat, and 'flattening' of the bank toe downslope of the root-mat through both scour and seepage erosion processes.

Banks which lack tea tree cover typically show scour of the bank in the 2-3 turbine power station operating level and a reduction in the slope of the bank toe through seepage process which are recorded as deposition by the erosion pins.

3.5.3 Photo monitoring

Photo monitoring of the erosion pin sites and prominent features, such as land slips, was completed in October 2014. Many of the sites correspond to features included in the Basslink and Interim Monitoring programs, and historical photos are contained in the Annual Basslink Monitoring Reports (Hydro Tasmania 2014 - Photo monitoring Appendices). Photos obtained in October 2014 and in March 2014 (or the most recent photo) are shown in Appendix C.

Observed changes at the photo monitoring sites were generally minor, and consistent with the prolonged high discharge from the power station, followed by a period of reduced usage. Observed changes include:

- Additional loss of vegetation on bank faces and back water channels owing to the sustained high power station discharge levels (P1E, P2-3, P2-4);

- Movement or removal of large and small woody debris from bank faces and bank toes (landslips P2-6 to P2-13);
- Scour of seepage features on bank toes, eg. In March 2014 bank toes were characterized by seepage features such as rilling whereas in October 2014, bank toes were smooth (P2-5, 3C); and
- Erosion of root mat (erosion pin sites 2H, 2L, 3E).

3.6 Conclusion

The October 2014 monitoring results are consistent with the understanding of geomorphic processes in the middle Gordon River, and how these processes relate to power station discharge. The high magnitude long-duration flow which has characterised the Gordon for the past few years has led to the removal of vegetation which had established on bank faces during the preceding period of low power station usage. The more recent shorter duration ‘peaking’ pattern at the station has resulted in evidence of seepage processes on the bank toes as well as scour on the upper bank faces.

The overall bank morphology is trending towards one characterised by low angle banks extended to an abrupt break in slope, above which the bank is characterised by a steep slope stabilised by terrestrial vegetation above the power station controlled high water level.

In October 2014, several observations were potentially linked to the increase in maximum discharge from the Gordon Power station. These include: the appearance of a new sand bar in the pool downstream of Abel Gorge, the removal of coatings and polishing of rock surfaces on rock faces in zone 2, and die back of vegetation within the area of increased inundation. These observations are not considered significant in the context of the geomorphology of the middle Gordon River, but demonstrate how even small changes to power station discharges lead to adjustments in the river.

4 Macroinvertebrates

4.1 Introduction

Macroinvertebrate sampling was conducted in spring (14-15 October) 2014 using the protocols established under the Basslink Monitoring Program for the Gordon River. Both quantitative (surber) and rapid bioassessment (RBA) sampling was conducted at monitoring sites in the Gordon River between the power station and the Franklin River confluence. This sampling was also conducted at five of the six established reference sites located in tributaries within the Gordon River catchment.

This chapter reports on the results of field sampling for macroinvertebrates in spring 2014, provides a comparison of these results with those for the pre-Basslink period years (2001-2005) and describes trends over the monitoring period to date.

Results were also compared with the spring season trigger values derived from pre-Basslink period data, as detailed in the Basslink baseline report.

4.2 Methods

4.2.1 Sample sites

The locations of the monitoring and reference sites are shown in in Figure 4-1 listed in Table 4-1. The Maxwell River reference site could not be sampled due to high river levels.

Table 4-1 Sites sampled in 2014 for macroinvertebrates.

River	Site Name	Site code	Distance from power station (km)	Easting	Northing
Gordon	Gordon R ds Albert Gorge (G4)	75	2	412980	5266630
	Gordon R ds Piguenit R (G4A)	74	3	412311	5266383
	Gordon R in Albert Gorge (G5)	72	5	410355	5266524
	Gordon R us Second Split (G6)	69	8	408005	5266815
	Gordon R ds Denison R (G9)	60	17	402896	5271211
	Gordon R us Smith R (G10)	57	20	402083	5273405
	Gordon R ds Olga R (G11A)	48	29	398178	5278476
	Gordon R @ Devil's Teapot (G15)	42	35	396804	5282486
Franklin	Franklin R ds Blackman's bend (G19)	Fr11	-	398562	5291239
Franklin	Franklin R @ Flat Is (G20)	Fr21	-	397939	5296733
Denison	Denison ds Maxwell R (G21)	De7	-	407206	5272718
Denison	Denison R us Truchanas Reserve (D1)	De35	-	417400	5282900
Jane	Jane R (J1)	Ja7	-	408100	5300400

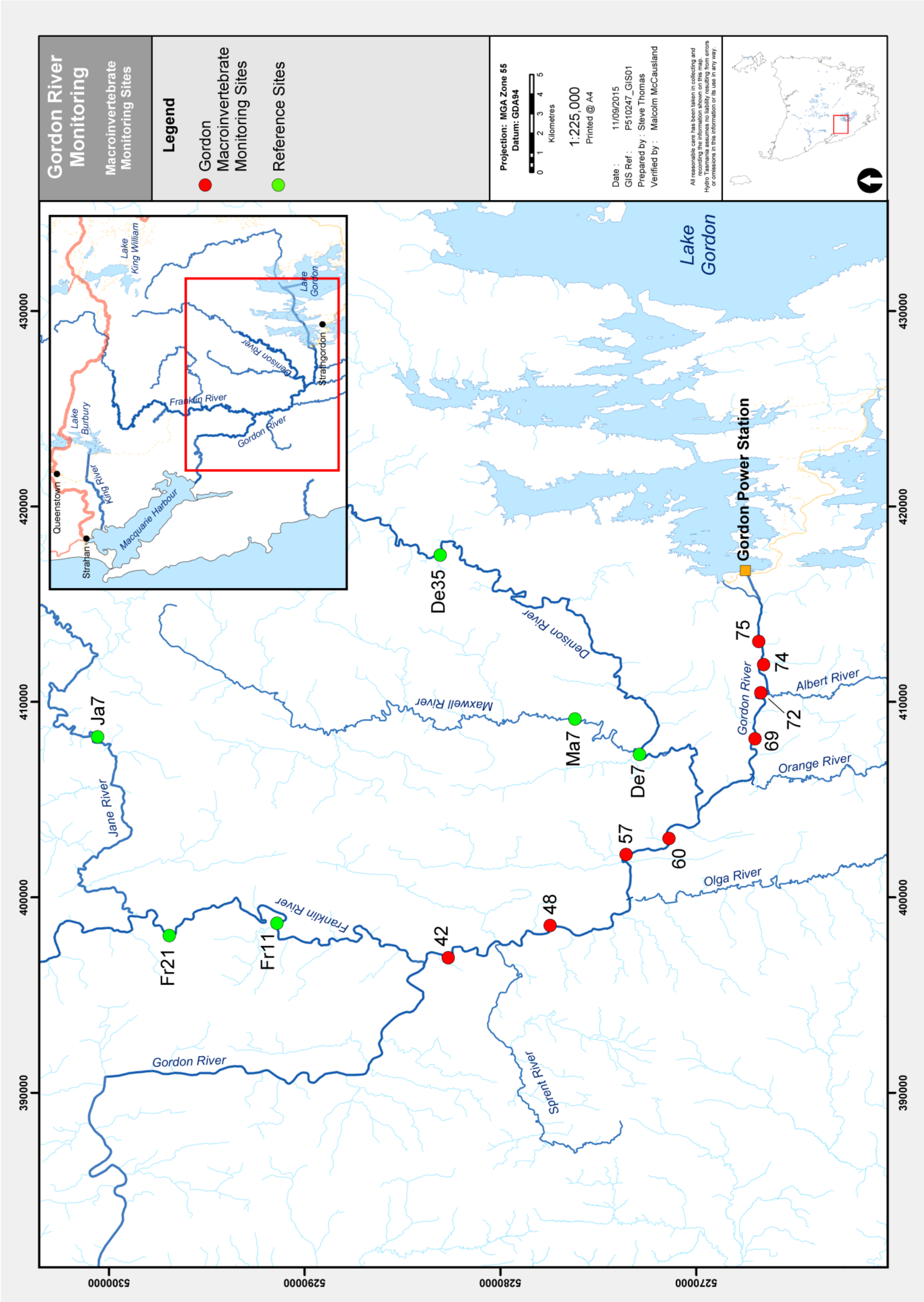


Figure 4-1: Map of locations of macroinvertebrate monitoring sites in the Gordon River and reference sites in the Jane, Maxwell, Denison and Franklin rivers.

4.2.2 Macroinvertebrate sampling

Sampling of Gordon River sites was conducted on 14 October 2014 and of reference river sites on 15 October 2014. One reference river site, site M1 (Ma7) could not be sampled due to high flows.

Quantitative sampling (surber sampling) and rapid bioassessment kick sampling (RBA) methods were conducted. 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 disturbing the substrate within the quadrate by hand to a depth of 10cm whereby attached macroinvertebrates are swept into the net; and
- Disturbing substrate by foot and hand immediately upstream of a standard 250 micron kick net over a distance of 10m (RBA).

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 random cell selection from a Marchant box subsampler. 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. Identification to genus and species level was conducted for the aquatic insect orders Ephemeroptera, Plecoptera, Trichoptera - the 'EPT' group fauna - using the most current taxonomic keys.

All analyses were conducted using the 20% (0.18 m^2) sub-sample data.

Two RBA samples were collected at each site. 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 family taxonomic level as described above.

4.2.3 Habitat variables

A set of standard habitat variables were recorded at each site and a number of variables were recorded from 1:25 000 maps. The habitat variables recorded are:

- per cent cover of substrate types (boulder, cobble, pebble, gravel, sand, silt and clay);
- per cent of site area covered by algae, moss, silt and detritus;
- site depth, temperature, conductivity, wetted width, bankfull width, flow and water clarity;
- extent of aquatic, overhanging, trailing and riparian vegetation; and
- per cent of site in habitat categories (riffle, run, pool and snag habitats).

4.2.4 Analysis

All RBA data was analysed using the spring season Hydro RIVPACS models developed by Davies et al. (1999), with O/Epa and O/Erk values derived using the RBA macroinvertebrate data in combination with key 'predictor' habitat variables. O/Epa is derived using presence/absence data and models derived from presence/absence reference site data. O/Erk is derived using rank abundance category data and models derived from rank abundance category reference data.

O/Epa and O/Erk scores range between 0 and 1. A zero value represents the condition where no expected taxa are found in the sample and a value of 1.0 represent the condition where all expected taxa are found. This range is divided into impairment bands for reporting purposes:

- D – extremely impaired;
- C – severely impaired;
- B – significantly impaired;
- A – unimpaired, or equivalent to reference; and
- X – more diverse than reference.

Trigger values were those derived for the Basslink program as detailed in the Basslink Baseline Report (Hydro Tasmania, 2005a). Values of each metric derived from the spring 2014 data were compared against the relevant spring season trigger values (shown graphically in this report). Plots of trends in metric values and abundances of selected families are presented.

4.3 Results

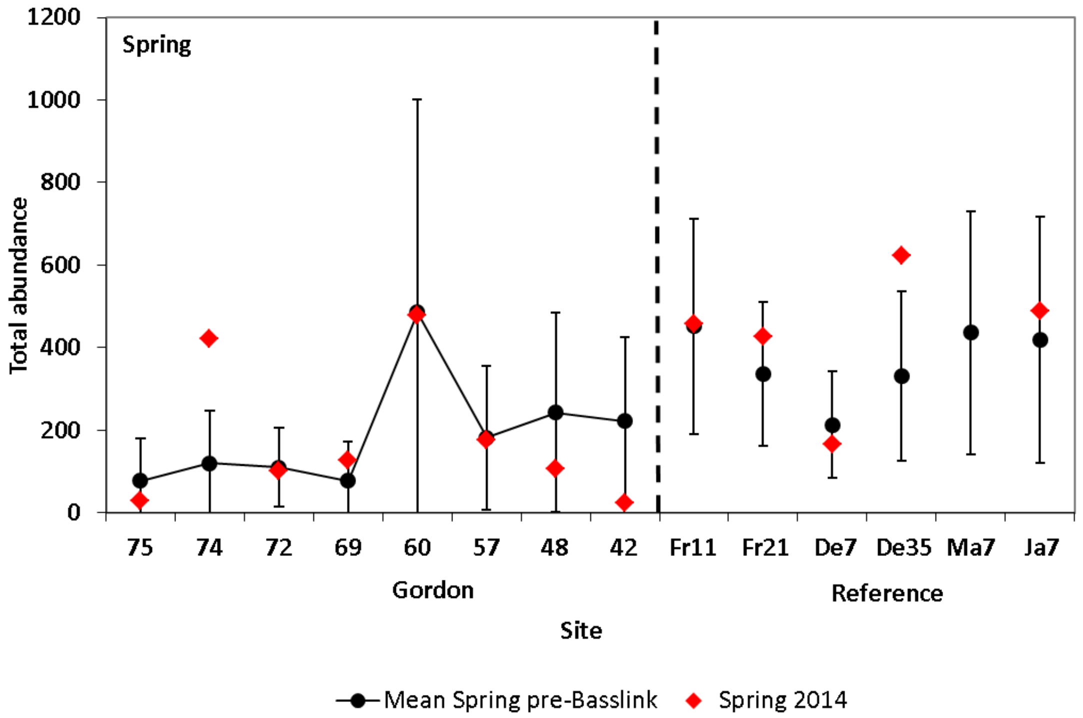
4.3.1 Quantitative data

The spring 2014 season quantitative surber sample data for family and EPT species are shown in Appendix D.1 and Appendix D.2, respectively.

Diversity and total abundance in the Gordon River at both family and species level fell generally within or close to the range observed in previous years across most sites (Figure 4-2, Figure 4-3). High abundance and diversity (23 to 25 families) were observed for three of the reference sites in the lower Franklin, Jane and Denison rivers.

The absolute abundance and richness of EPT species was generally lower than the pre-Basslink means in zone 2 (Figure 4-4) in spring 2014. This was not the case for reference sites. The relative (proportional) abundance of EPT species was lower than the pre-Basslink means at six of the eight Gordon River sites (Figure 4-4).

The community compositional similarity of all zone 1 Gordon River sites relative to the reference sites was generally similar to the pre-Basslink means, as measured by the mean Bray Curtis Similarity measure based on both abundance and presence/absence EPT species data (Figure 4-5).



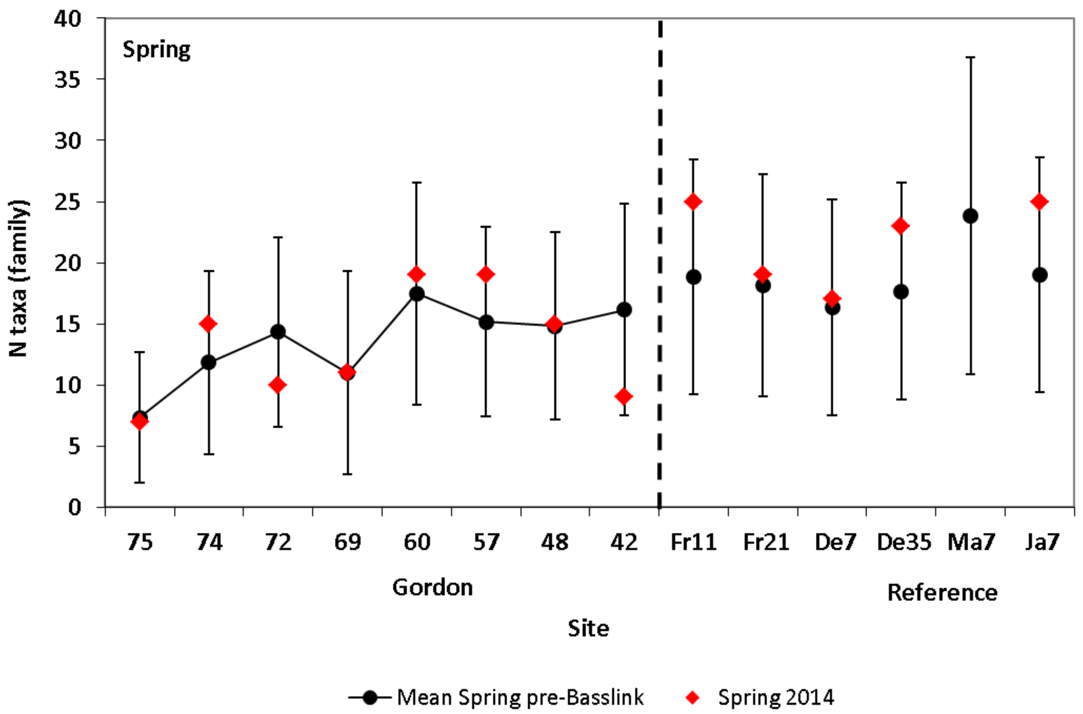
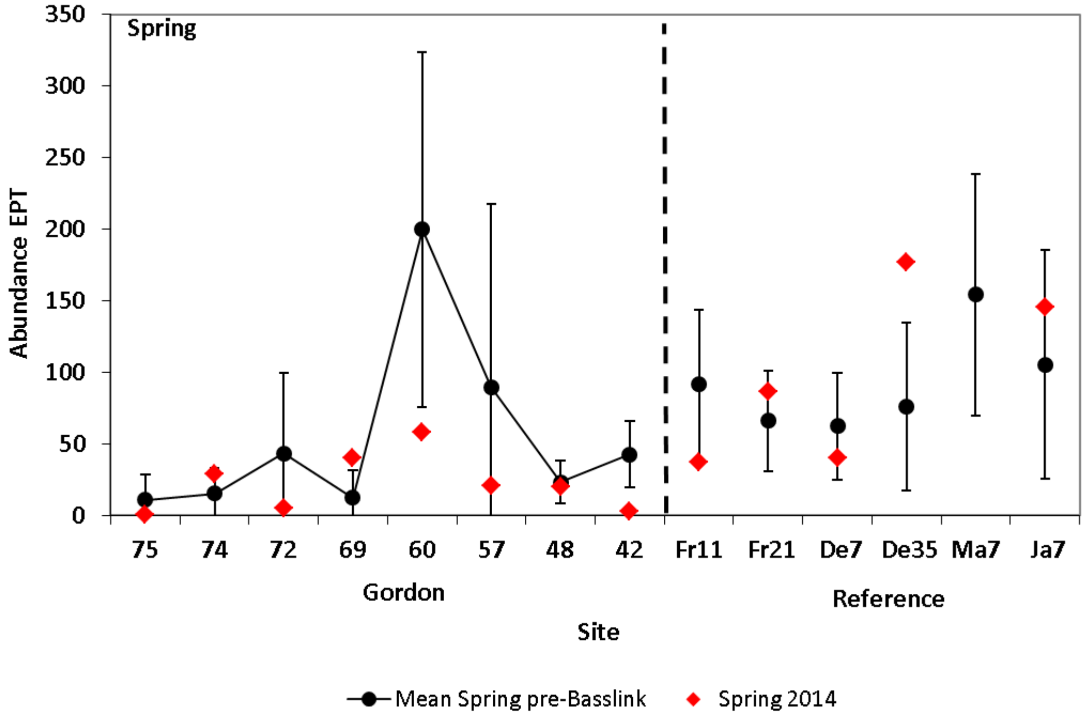


Figure 4-2 Comparison of total abundance of all benthic macroinvertebrates and diversity (number of taxa at family level) for spring 2014 with spring values from previous years. Error bars indicate standard deviations around the pre-Basslink 2002-05 mean.



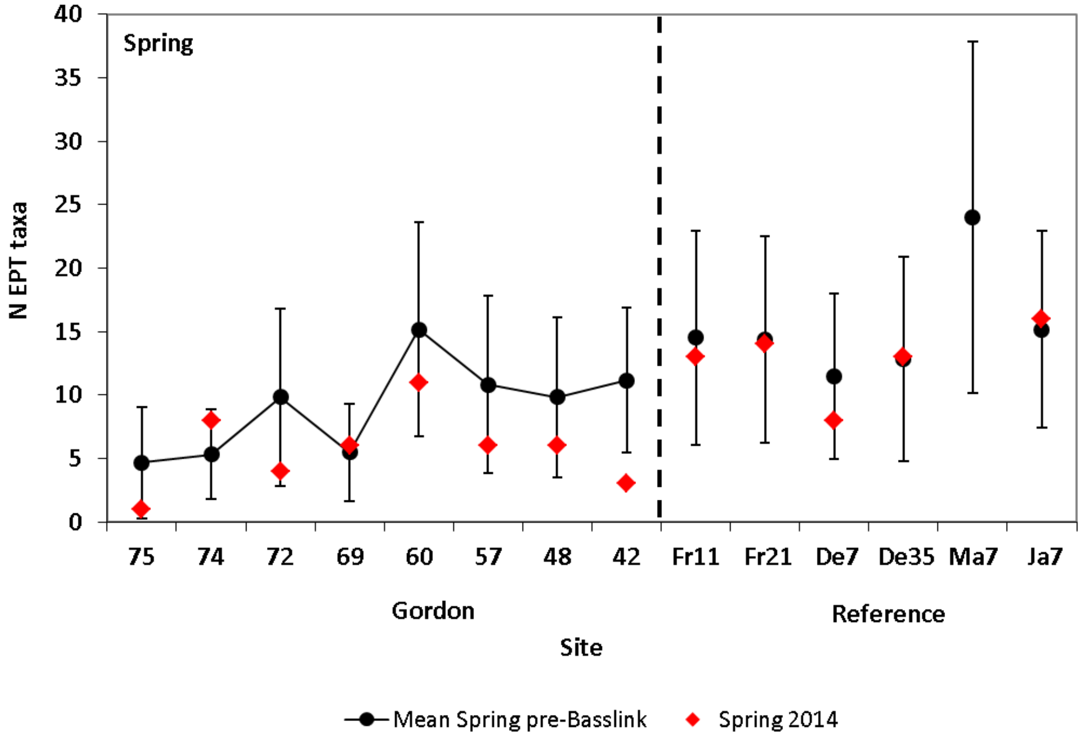


Figure 4-3 Comparison of total abundance and number of benthic EPT taxa (genus and species) for spring 2014 with spring values from previous years. Error bars indicate standard deviations around the pre-Basslink 2002-05 mean.

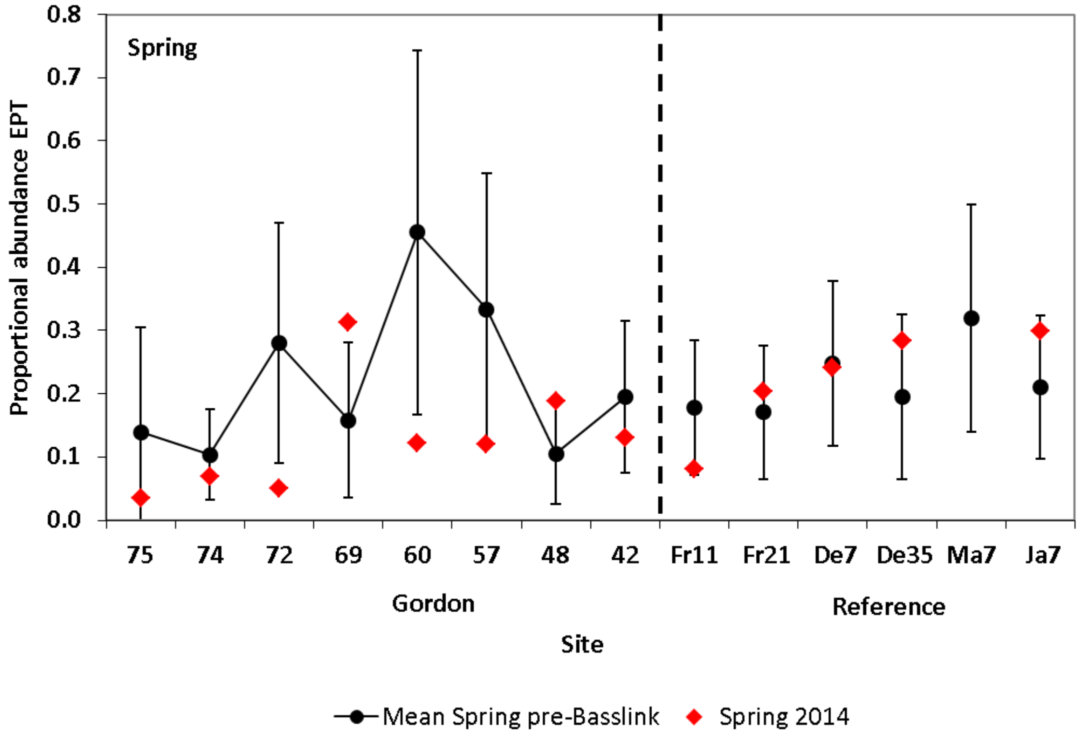
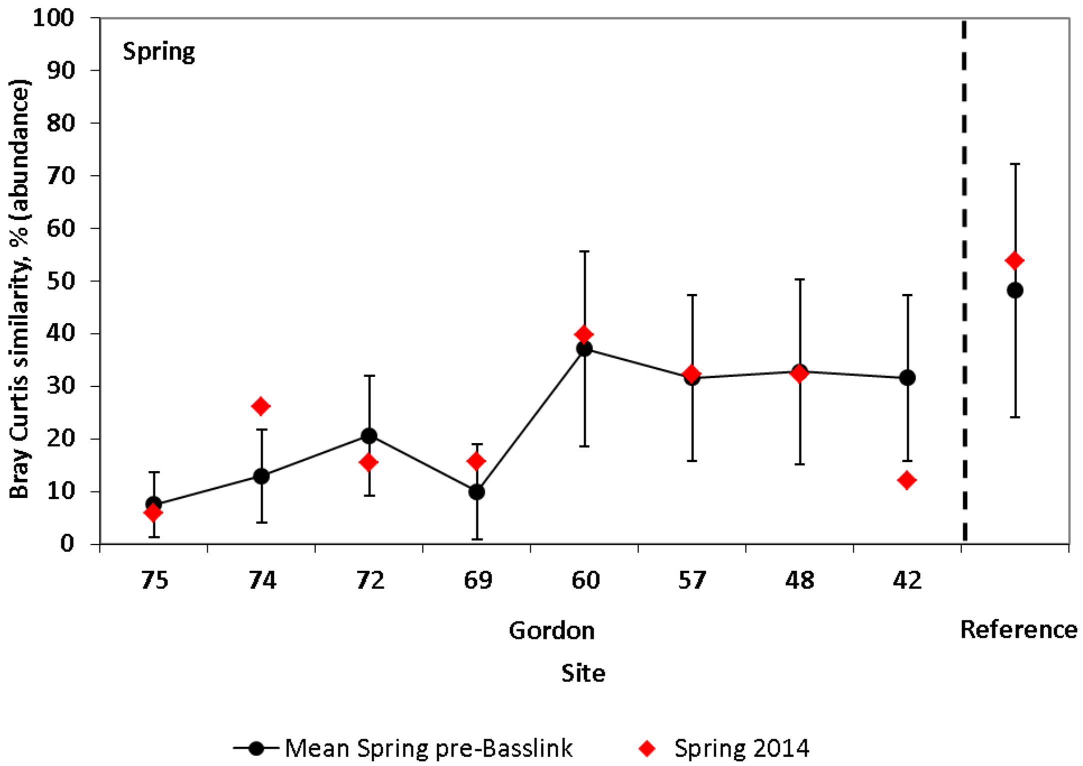


Figure 4-4 Comparison of proportion of total benthic macroinvertebrate abundance represented by EPT species for spring 2014 with spring values from previous years. Error bars indicate standard deviations around the pre-Basslink 2002-05 mean.



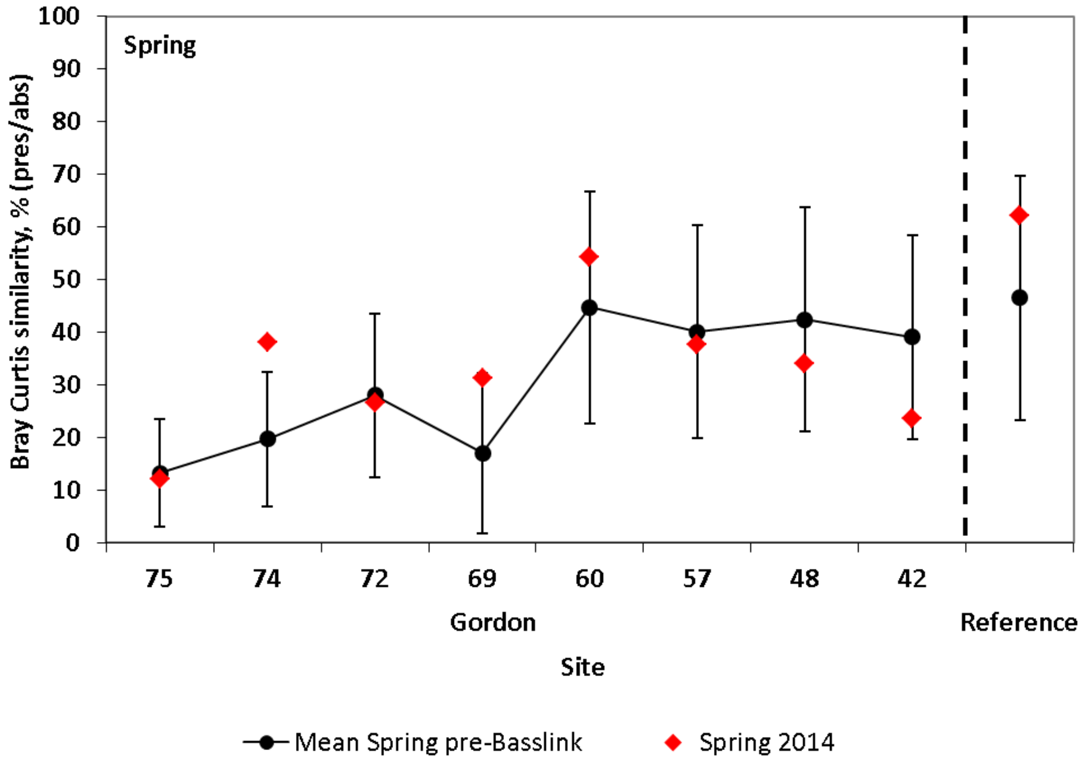


Figure 4-5 Comparison of values for the mean Bray Curtis similarity between each sampled site and the reference sites for spring 2014 with spring values from previous years. Similarities are calculated with either abundance data (square root transformed) or presence/absence data. Error bars indicate standard deviations around the pre-Basslink 2002-05 mean. Note that the value for reference sites represents the mean of similarities between each reference site and the other reference sites sampled at the same time.

4.3.2 RBA data

The complete spring season RBA data are shown in Appendix D.3. O/Epa and O/Erk values and their impairment bands are presented in Figure 4-6 and Table 4-2.

O/Epa and O/Erk values in spring 2014 fell below pre-Basslink means for all zone 1 Gordon River sites. Most zone 2 sites were at or close to pre-Basslink mean values (Figure 4-6). Four of the five reference sites sampled also had O/E values below pre-Basslink means.

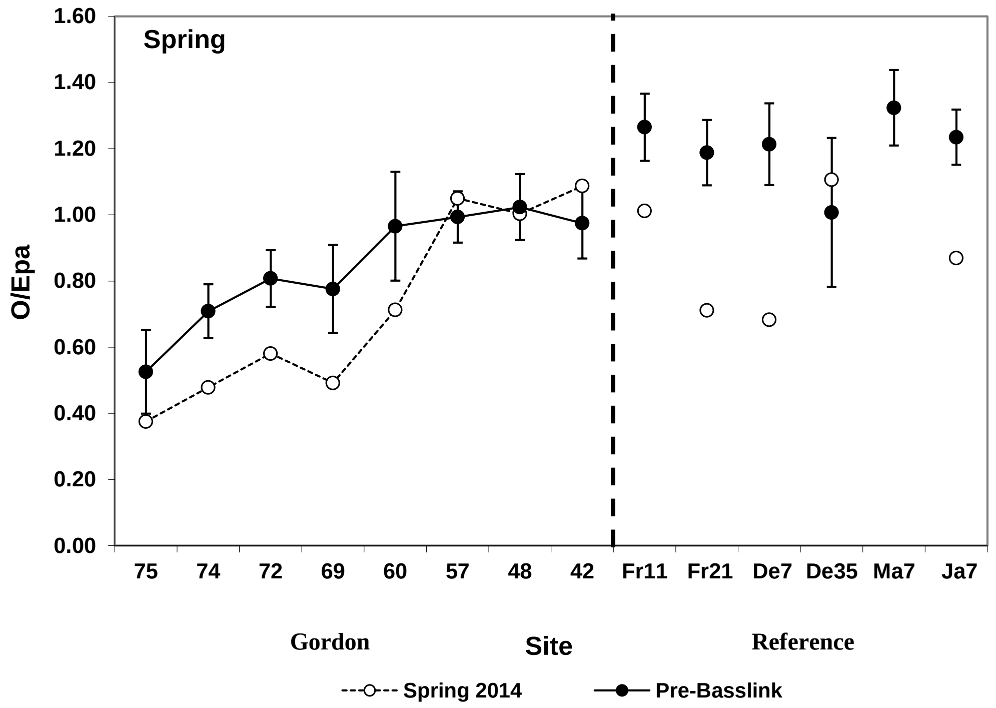
O/Epa values for spring 2014 in zone 1 of the Gordon, as well as for spring 2014 combined, were significantly different from pre-Basslink means (by t-tests of spring pre-Basslink means with 2014 values, $p < 0.025$). A similar result was observed for O/Erk. No significant difference was detected between 2014 and pre-Basslink values for either O/Epa or O/Erk in zone 2.

Four of the five reference sites sampled had O/E values below pre-Basslink means for these two metrics in spring 2014 (Figure 4-6). Reference site values for O/Epa and O/Erk were however not significantly different from pre-Basslink means for spring 2014 (by paired t-tests of spring pre-Basslink means with 2014 values, $p > 0.15$).

These results show that a significant decline in O/E values (20-25%) was observed in the Gordon River zone 1 relative to the pre-Basslink period. A smaller and less statistically consistent decline was observed at reference sites, with losses of different families indicating different likely causes. No such decline in O/E values was observed in zone 2.

Table 4-2: O/Epa and O/Erk values for all sites sampled in spring 2014. Iindividual replicate and mean value are provided with corresponding impairment bands.

River	Site	Replicate	Spring 2014			
			O/Epa	Band	O/Erk	Band
Gordon R	75	1	0.38	B	0.47	B
		2	0.38	B	0.47	B
		Mean	**0.38**	**B**	**0.47**	**B**
	74	1	0.44	B	0.46	B
		2	0.52	B	0.52	B
		Mean	**0.48**	**B**	**0.49**	**B**
	72	1	0.58	B	0.57	B
		2	0.58	B	0.57	B
		Mean	**0.58**	**B**	**0.57**	**B**
	69	1	0.53	B	0.53	B
		2	0.45	B	0.47	B
		Mean	**0.49**	**B**	**0.50**	**B**
	60	1	0.75	A	1.00	A
		2	0.67	B	1.06	A
		Mean	**0.71**	**B**	**1.03**	**A**
	57	1	1.12	A	1.12	A
		2	0.97	A	0.94	A
		Mean	**1.05**	**A**	**1.03**	**A**
	48	1	0.96	A	0.91	A
		2	1.04	A	0.98	A
		Mean	**1.00**	**A**	**0.94**	**A**
	42	1	1.20	X	1.12	A
		2	0.97	A	0.82	A
		Mean	**1.09**	**A**	**0.97**	**A**
Franklin R	Fr11	1	0.97	A	1.00	A
		2	1.05	A	1.05	A
		Mean	**1.01**	**A**	**1.02**	**A**
	Fr21	1	0.82	A	0.88	A
		2	0.60	B	0.71	B
		Mean	**0.71**	**B**	**0.79**	**A**
Denison R	De7	1	0.68	B	0.64	B
		2	0.68	B	0.64	B
		Mean	**0.68**	**B**	**0.64**	**B**
	De35	1	0.95	A	0.97	A
		2	1.26	X	1.27	X
		Mean	**1.11**	**A**	**1.12**	**A**
Maxwell R	Ma7	1				
		2				
		Mean	**NA**	**NA**	**NA**	**NA**
Jane R	Ja7	1	0.87	A	0.79	A
		2	0.87	A	0.79	A
		Mean	**0.87**	**A**	**0.79**	**A**



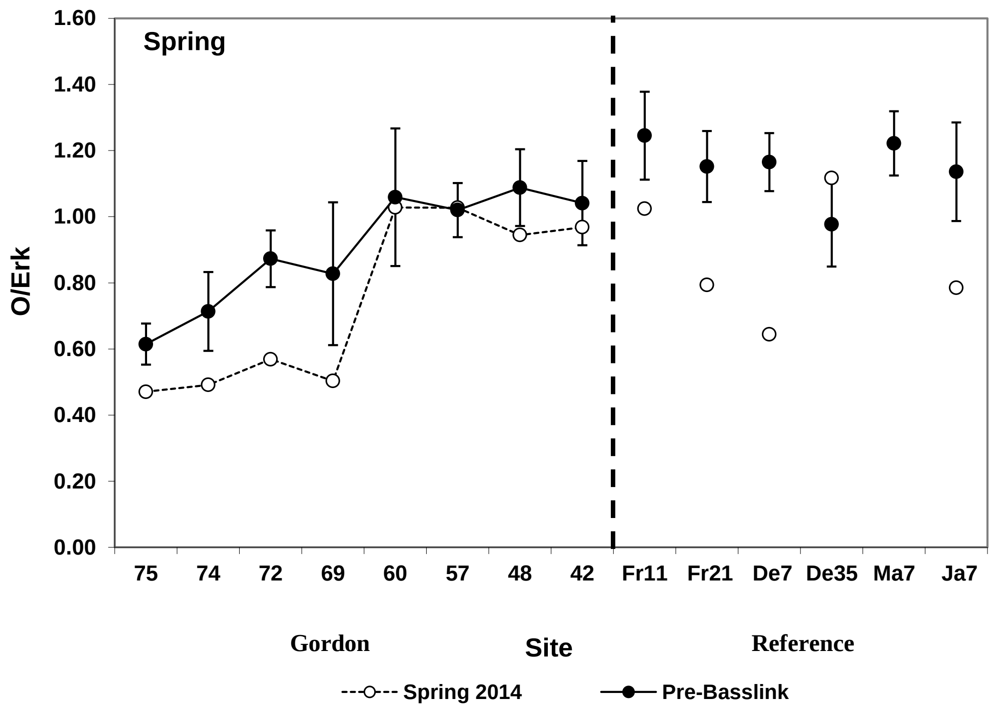


Figure 4-6 Comparison of O/Epa and O/Erk values for spring 2014 with values from previous years. Note high O/Epa values at sites 48 and 69 – 74 upstream of Denison River. Error bars indicate standard deviations around the pre-Basslink 2002-05 mean.

4.3.3 Summary

Overall, the diversity at family level and the abundance and diversity of EPT species, as well as measures of compositional similarity to reference, were similar to pre-Basslink values for Gordon River sites in spring 2014.

By contrast, both measures of the presence and relative abundance of expected macroinvertebrate families (O/Epa and O/Erk) were consistently lower than pre-Basslink means and ranges for zone 1 in the Gordon River. This implies a loss of expected families, coupled with a reduction in their relative abundance, in zone 1 compared with pre-Basslink values. The decline in O/E scores was not observed in the lower Gordon River below the Denison (zone 2) or reference sites.

4.4 Comparisons with Triggers

4.4.1 Results

Nine metrics were developed for assessing the degree of any changes in benthic macroinvertebrates in the Gordon River due to Basslink operations. These metrics are grouped into five overall components as outlined in Table 4-3.

Table 4-3 Macroinvertebrate components and metrics identified for assessing change.

Components	Metrics
Community Structure	Bray Curtis (abundance) O/Erk
Community Composition	Bray Curtis (pres/abs data) O/Epa
Taxonomic richness	N Taxa (fam) N EPT Species
Ecologically significant species	Proportion of total Abundance as EPT Abundance EPT
Biomass / productivity	Total abundance

Trigger values for these biological metrics were established based on the 95th percentile of pre-Basslink values. These trigger values are used in reporting on whether limits of acceptable change (LOAC) have been exceeded post-Basslink. Triggers were developed for each individual site in the Gordon River, as well as for the entire river ('whole of river', WOR) and zones within the river. Two zones have been described for benthic macroinvertebrates:

- zone 1-upstream of the Denison River junction (incorporating sites 69 to 75); and
- zone 2-downstream of the Denison River junction (incorporating sites 42 to 60).

Values of all metrics for spring 2014 are shown in Appendix D.4. Plots of the trigger levels for each metric are shown in Figure 4-7 to Figure 4-11 along with the value for the metric recorded in spring 2014 at whole of river (WOR) and zone levels.

4.4.2 Trigger status

The following section summarises and comments on the observations for spring 2014 in comparison with the biological trigger values.

4.4.2.1 Community Structure

Bray Curtis (abundance): All values fall within trigger bounds (Figure 4-7).

Comment – Overall within trigger bounds.

O/Erk: Values for whole of river (WOR) and for zone 1 fell below the lower trigger bound (Figure 4-7). This is the second such trigger exceedance for this metric, and follows an autumn 2014 value that was below the trigger bound. It indicates a reduced relative abundance of several expected families, as well as loss of several families. This is a characteristic response to sustained high flows in the Gordon River.

The value for zone 2 fell within the trigger bounds.

Comment – Below trigger bounds in zone 1 due to the impact of sustained high power station discharges prior to sampling.

4.4.2.2 Community Composition

Bray Curtis (pres/abs data): All values fell within trigger bounds (Figure 4-8). A low value close to the lower trigger bound for the WOR case.

Comment – Overall within trigger bounds.

O/Epa: Value for both WOR and zone 1 were below the lower trigger bound (Figure 4-8), though only marginally lower for the WOR case. A low value within the trigger bounds was observed for zone 2.

This is the second such trigger exceedance for this metric, following that observed in autumn 2014. This is due to the loss of several expected families and is a response to sustained high flows in the Gordon River preceding sampling.

Comment – below lower trigger bounds due to the impact of sustained high power station discharges prior to sampling.

4.4.2.3 Taxonomic richness

N Taxa (fam): All values fell within trigger bounds (Figure 4-9), however the WOR and zone 2 cases were in the lower levels of the trigger bounds.

Comment – Overall within trigger bounds.

N EPT Species: The zone 1 value, though low, fell within trigger bounds (Figure 4-9). WOR and zone 2 values both fell below the lower trigger bound.

Comment –below trigger bounds for WOR and zone 2.

4.4.2.4 Ecologically significant species

Proportion of total abundance as EPT: Values for WOR and both zones 1 and 2 were low but within trigger bounds (Figure 4-10).

Comment – Overall within trigger bounds, though marginal for the WOR case.

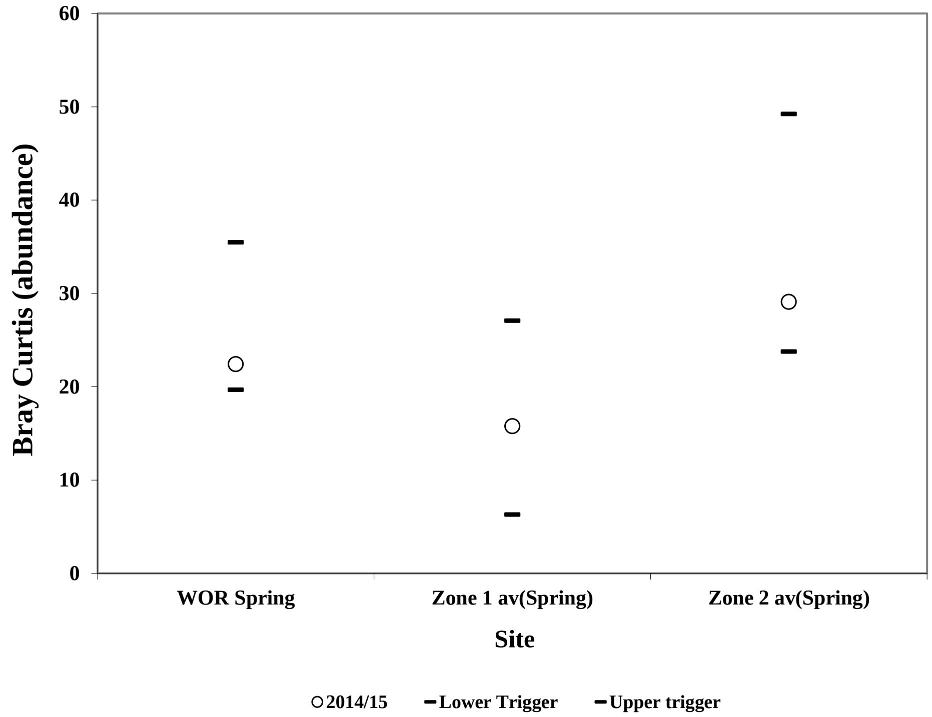
Abundance EPT: Values exceeded the upper trigger bound for WOR and zone 1 (Figure 4-10).

Comment – Upper exceedances not of environmental concern.

4.4.2.5 Biomass/productivity

Total abundance: All values fell within trigger bounds (Figure 4-11).

Comment – Within trigger bounds.



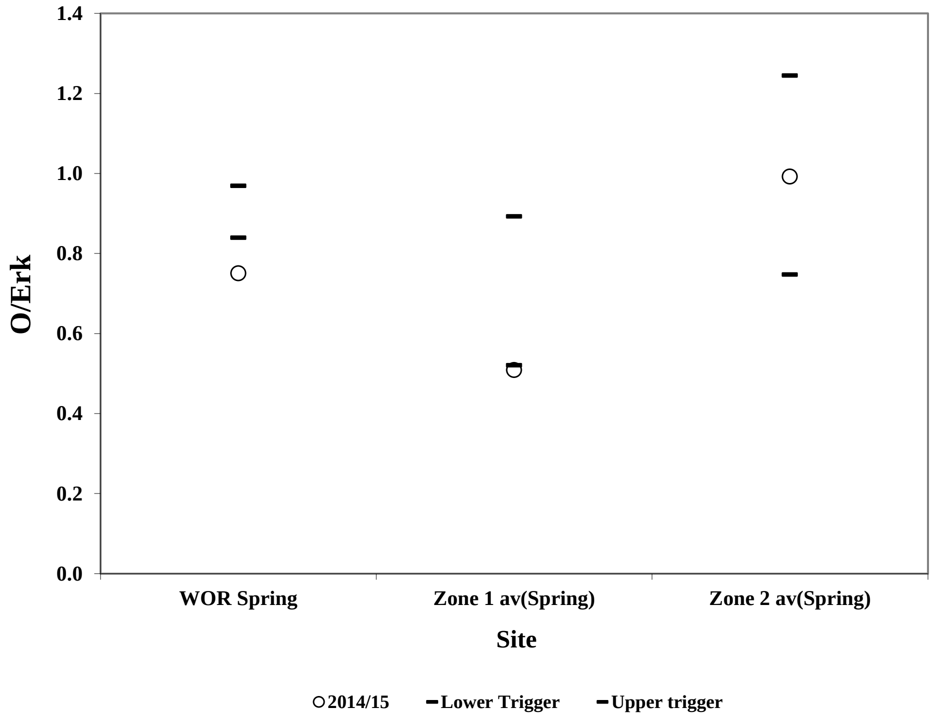
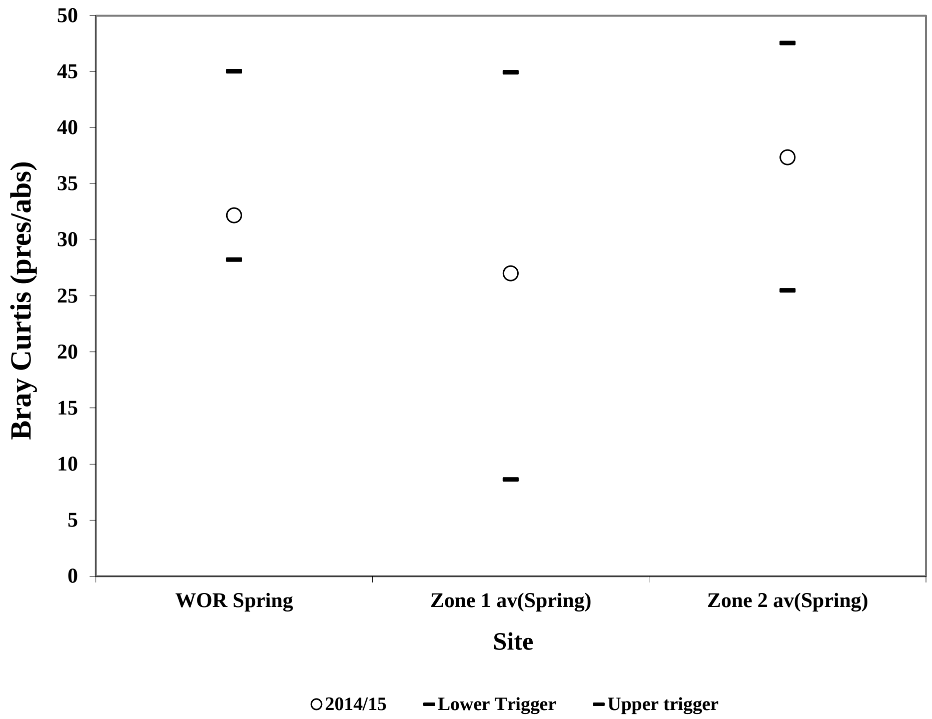


Figure 4-7 Community structure metric values for spring 2014 compared with upper and lower LOAC Trigger values in the Gordon River for the following cases: WOR = Whole of River (spring season), Zones 1 and 2 (spring season). Trigger values based on the 95 percentile of pre-Basslink data.



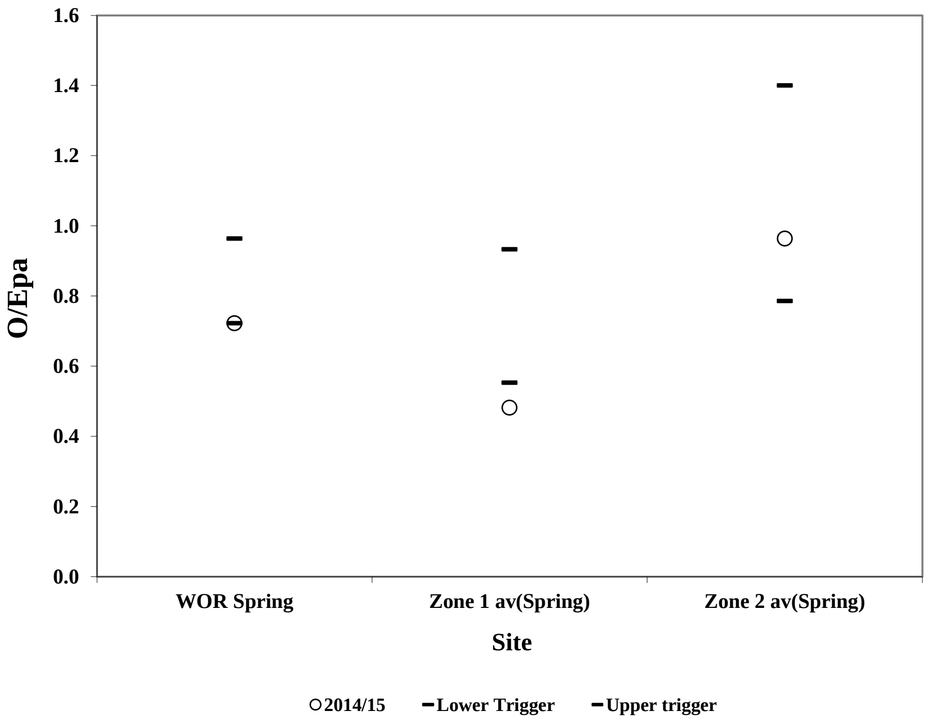
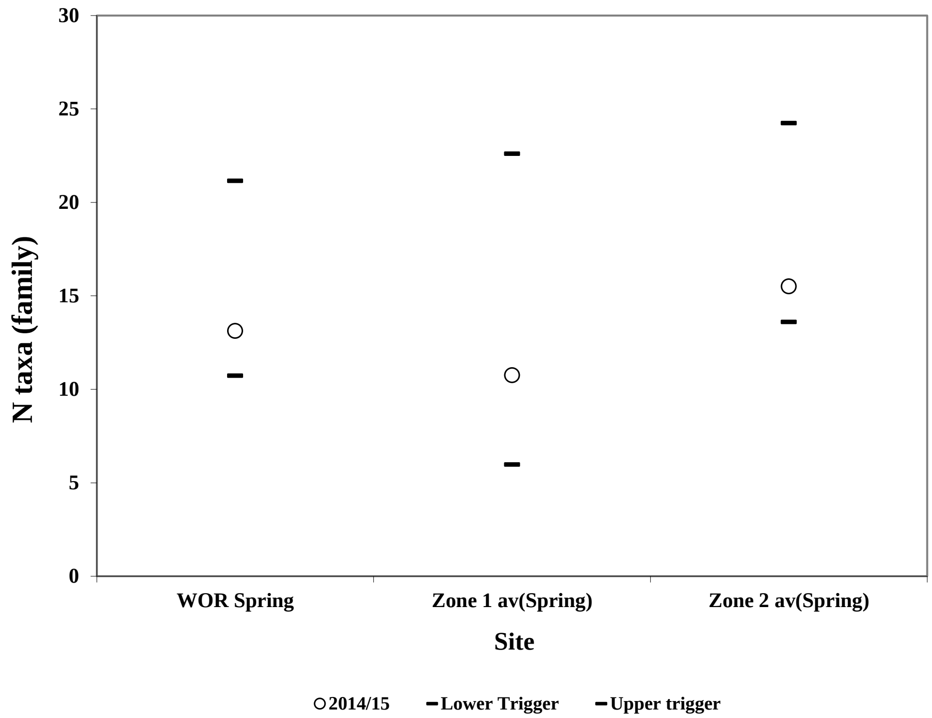


Figure 4-8 Community Composition metric values for spring 2014 compared with upper and lower LOAC Trigger values in the Gordon River for the following cases: WOR = Whole of River (spring season), Zones 1 and 2 (spring season). Trigger values based on the 95 percentile of pre-Basslink data.



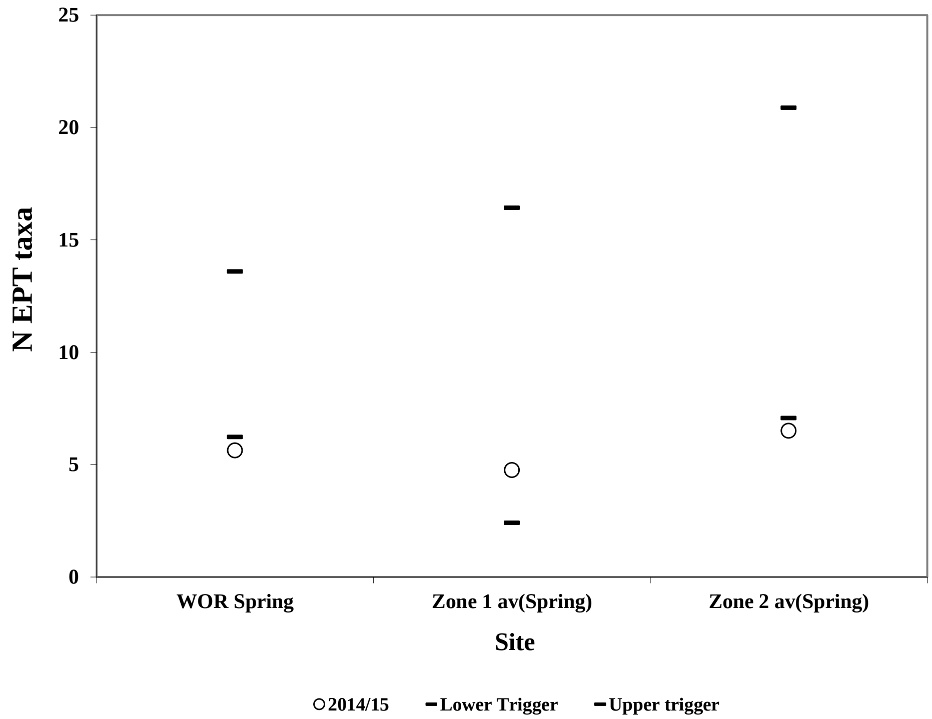
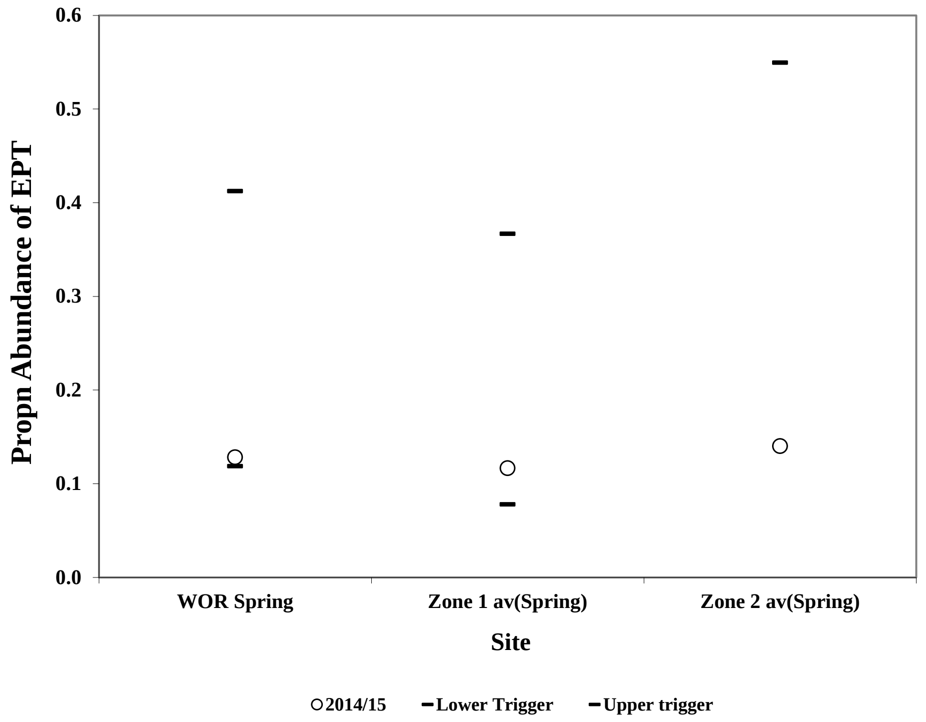


Figure 4-9 Taxonomic Richness metric values for spring 2014 compared with upper and lower LOAC Trigger values in the Gordon River for the following cases: WOR = Whole of River (spring season), Zones 1 and 2 (spring season). Trigger values based on the 95 percentile of pre-Basslink data.



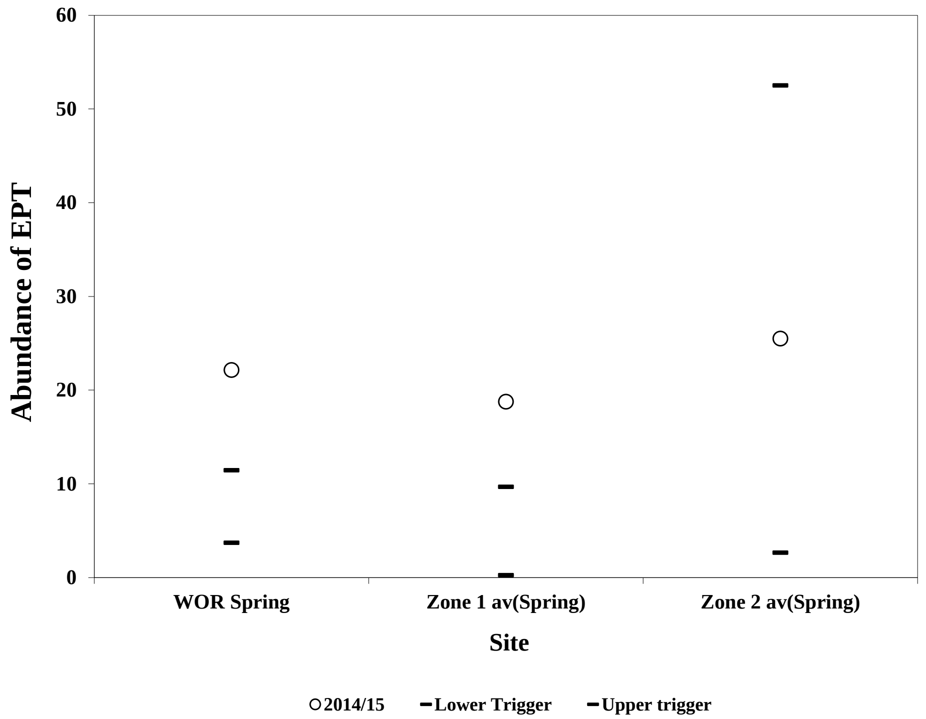


Figure 4-10 Ecologically significant species metric values for spring 2014 compared with upper and lower LOAC Trigger values in the Gordon River for the following cases: WOR = Whole of River (spring season), Zones 1 and 2 (spring season). Trigger values based on the 95 percentile of pre-Basslink data.

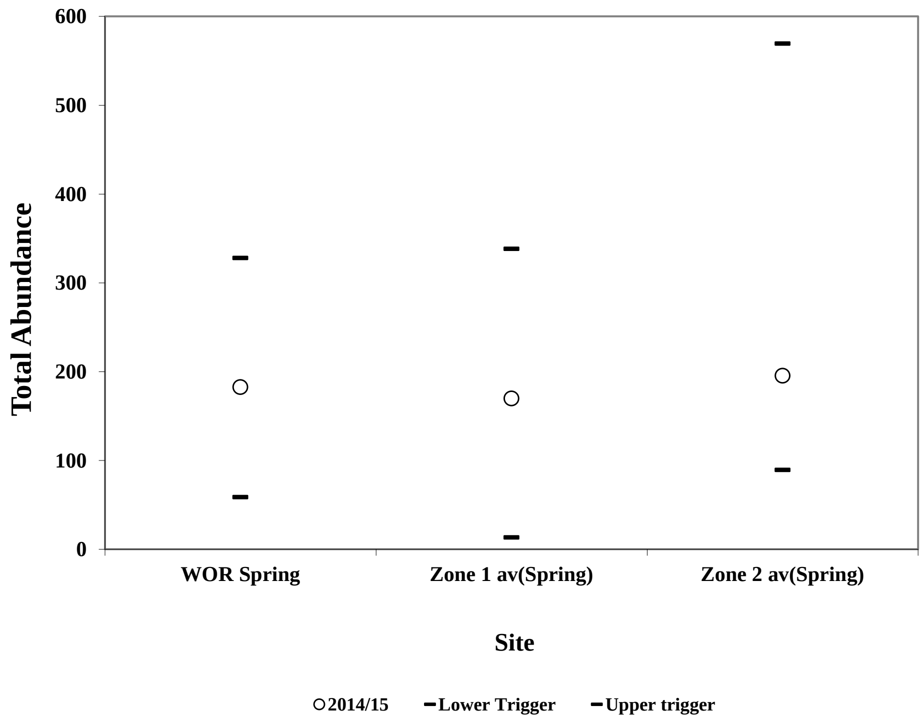


Figure 4-11 Biomass/Productivity metric values for spring 2014 compared with upper and lower LOAC Trigger values in the Gordon River for the following cases: WOR = Whole of River (spring season), Zones 1 and 2 (spring season). Trigger values based on the 95 percentile of pre-Basslink data.

4.5 Long-term trends

4.5.1 Univariate indicators

Trends in all metrics are shown in Figure 4-12 to Figure 4-16. As in previous years, the value of all metrics is predominantly highest in reference sites, lowest in zone 1 and intermediate in zone 2. Most metrics show no overall monotonic trend over the entire sampling period in the Gordon River, and are broadly consistent in values with time (with zone 1 being a recent exception). Some recent post-Basslink trends are however apparent.

The values of O/Epa, O/Erk and the number of EPT species and their proportional abundance fell in 2013-14 to levels not experienced previously (Figure 4-12, Figure 4-13, Figure 4-14). These values remained low or declined further in spring 2014. This represents a significant and continued post-Basslink decline in macroinvertebrate condition in zone 1.

No substantive overall post-Basslink increases in metric values have been observed in zone 2, though the number of EPT species declined to its lowest level observed to date in spring 2014 (Figure 4-13).

Zone 2 continues to be biologically intermediate between zone 1 and the reference rivers in macroinvertebrate composition and temporal dynamics, reflecting the substantial influence of the Denison River and other tributary rivers. This is also reflected in its Bray Curtis similarity to reference rivers which are generally higher than for zone 1 (Figure 4-15).

Metric values for reference rivers have generally been more stable over the entire monitoring period than those for the Gordon River (Figure 4-12 to Figure 4-16).

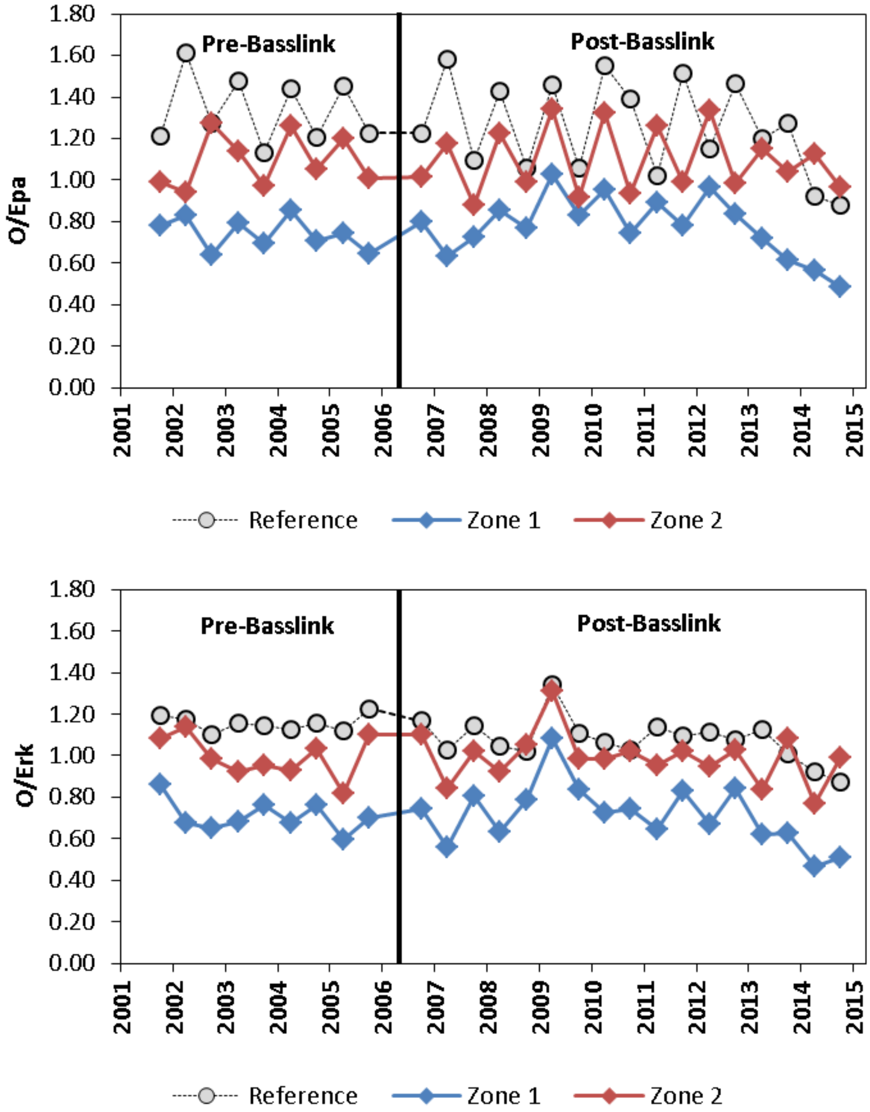


Figure 4-12 Mean O/Epa and O/Erk metric values for each zone in the Gordon river and reference rivers on each sampling occasion. Vertical line indicates initiation of Basslink operations.

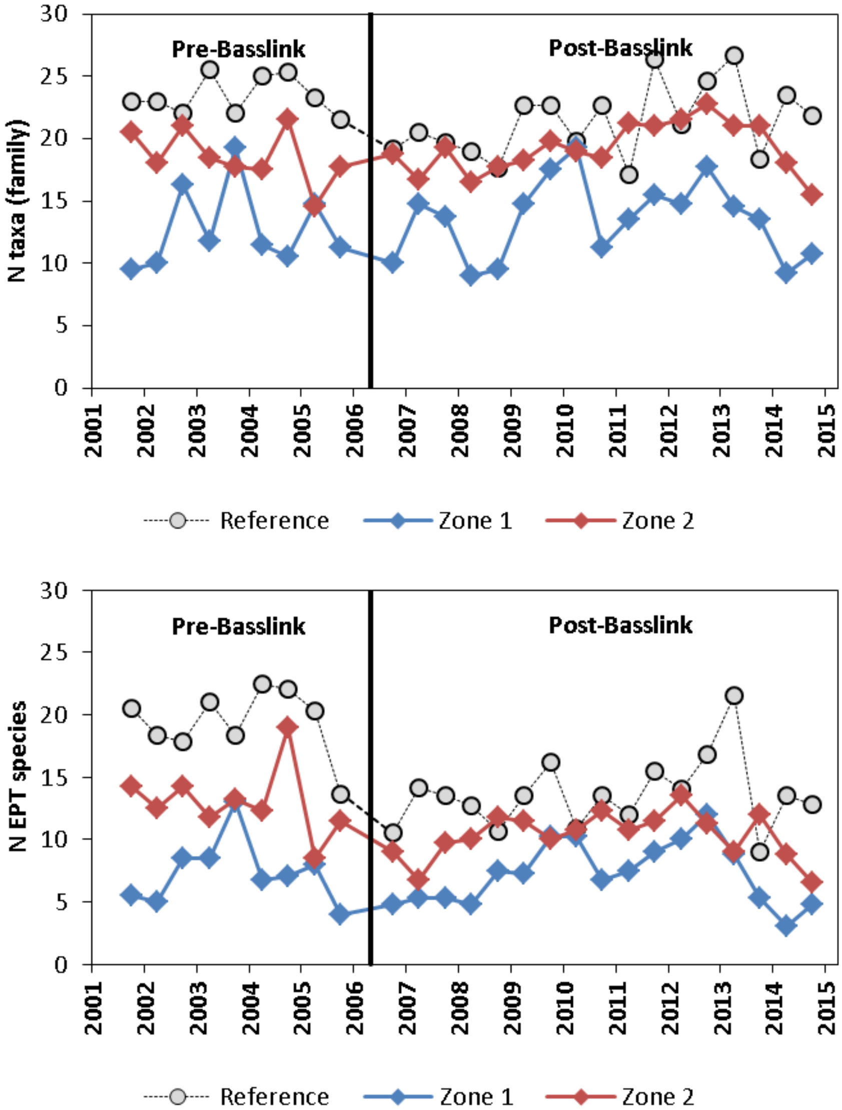
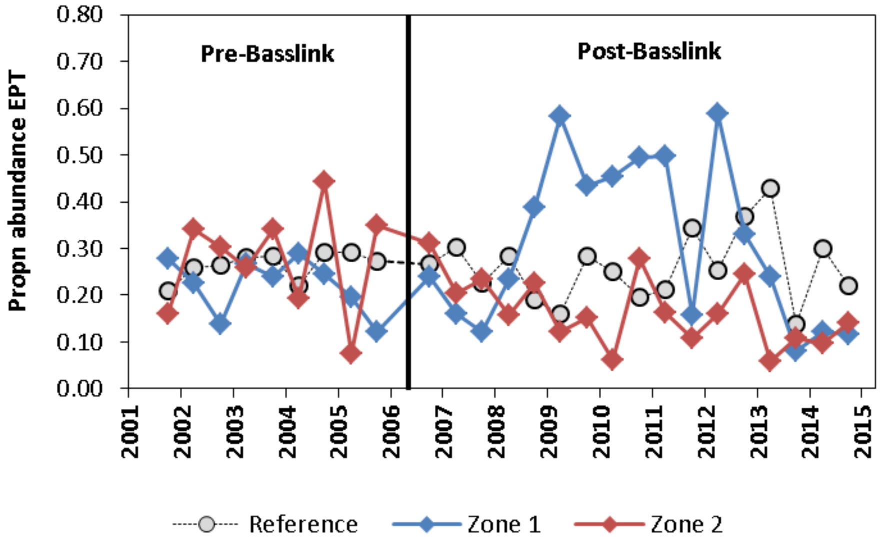


Figure 4-13 Mean N taxa (family) and N EPT species metric values for each zone in the Gordon River and reference rivers on each sampling occasion. Vertical line indicates initiation of Basslink operations.



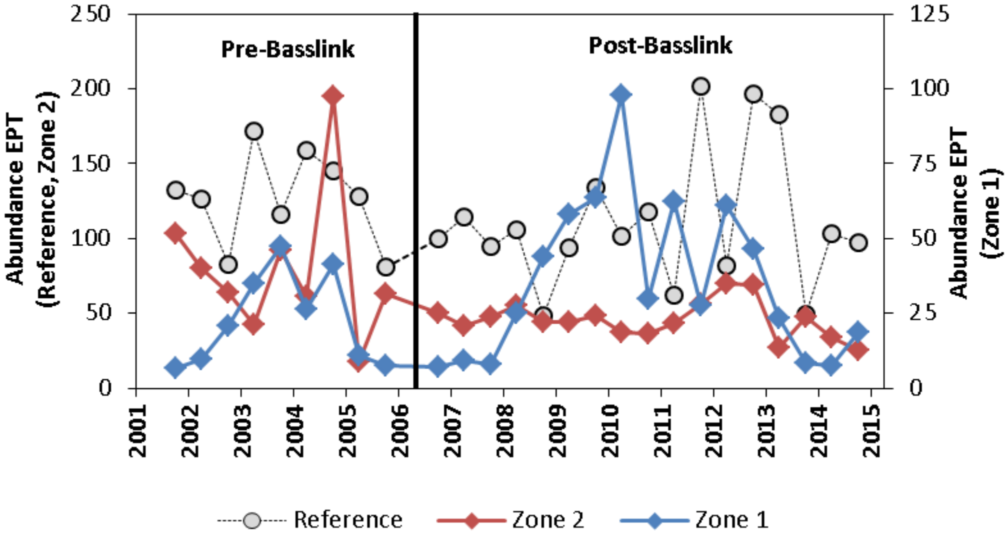


Figure 4-14 Mean Proportional abundance and absolute abundance of EPT taxa metric values for each zone in the Gordon River and reference rivers on each sampling occasion. Vertical line indicates initiation of Basslink operations.

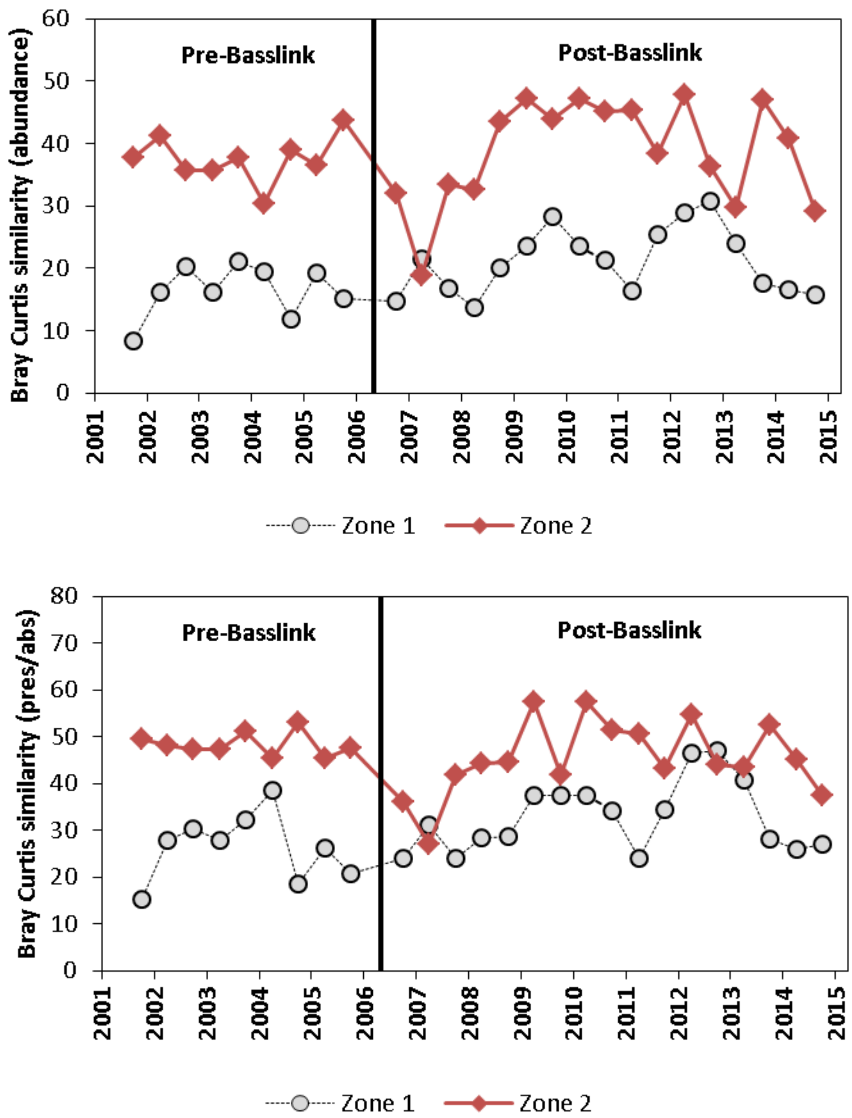


Figure 4-15 Mean Bray Curtis Similarity metric values between each zone in the Gordon River and the reference rivers on each sampling occasion. Vertical line indicates initiation of Basslink operations.

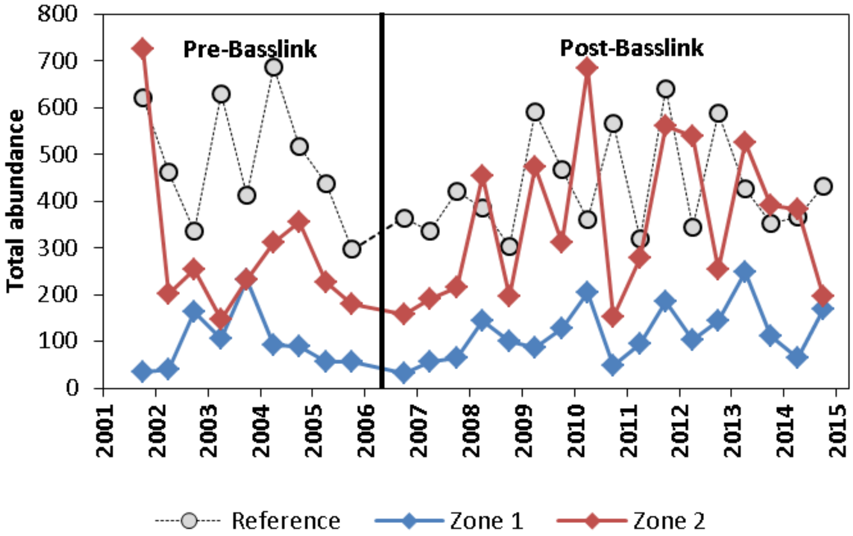


Figure 4-16 Mean total benthic macroinvertebrate abundance metric values for each zone in the Gordon River and reference rivers on each sampling occasion. Vertical line indicates initiation of Basslink operations.

4.6 Conclusion

Sampling was conducted successfully according to the requirements of the Gordon River monitoring program for all sites, with the exception of reference site Ma7 (where high flows precluded access).

High power station discharges in 2013-14 appear to have sustained trigger exceedances for the metrics O/Epa, O/Erk (Zone 1 and whole of river) and for the number of EPT species (Zone 2 and whole of river). During 2014 each of these metrics fell to levels not previously observed during the Basslink monitoring program, and below their respective lower trigger bound.

The current status for the nine year post-Basslink period is:

- six of the nine macroinvertebrate metrics had values within the trigger bounds; and
- upper trigger bound exceedances for abundance of EPT (whole of river and spring).

The trigger exceedances observed for O/Epa, O/Erk and the number of EPT species during 2014 indicate that the overall condition of the macroinvertebrate community has declined to below pre-Basslink levels.

The upper trigger level exceedances representing improvement in biological condition relative to pre-Basslink conditions have not been as distinct since spring 2013. Only the abundance of EPT species exceeds upper triggers in spring 2014, and to a lower extent than previously.

Inter-annual variations in power station release patterns, particularly the incidence of sustained peaking and high flows, drive large swings in metric values. The latter appear to have caused a general decline in 2013-14, which was sustained and observed in the most recent monitoring in spring 2014.

5 References

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A Appendix A: Power station discharges graphed per month

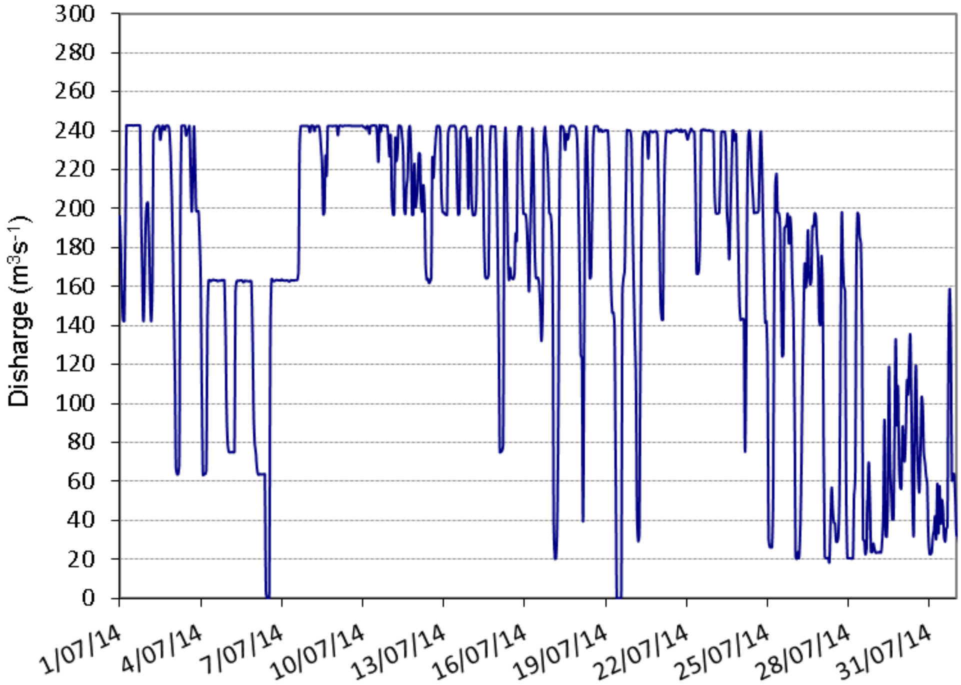

Figure A.1: Gordon Power Station discharge (hourly data) for July 2014.

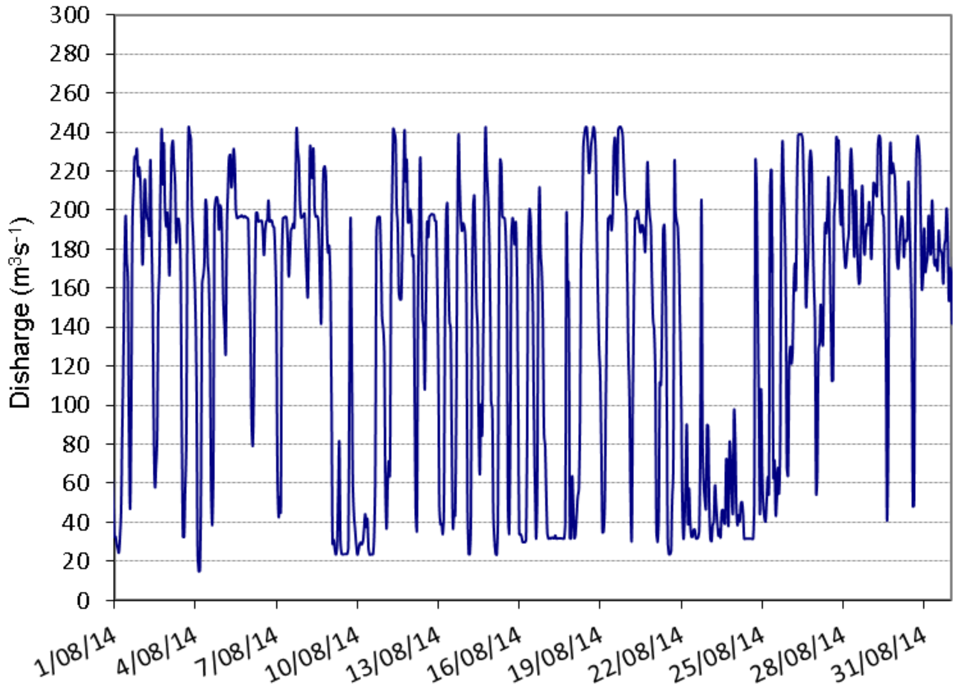

Figure A.2: Gordon Power Station discharge (hourly data) for August 2014.

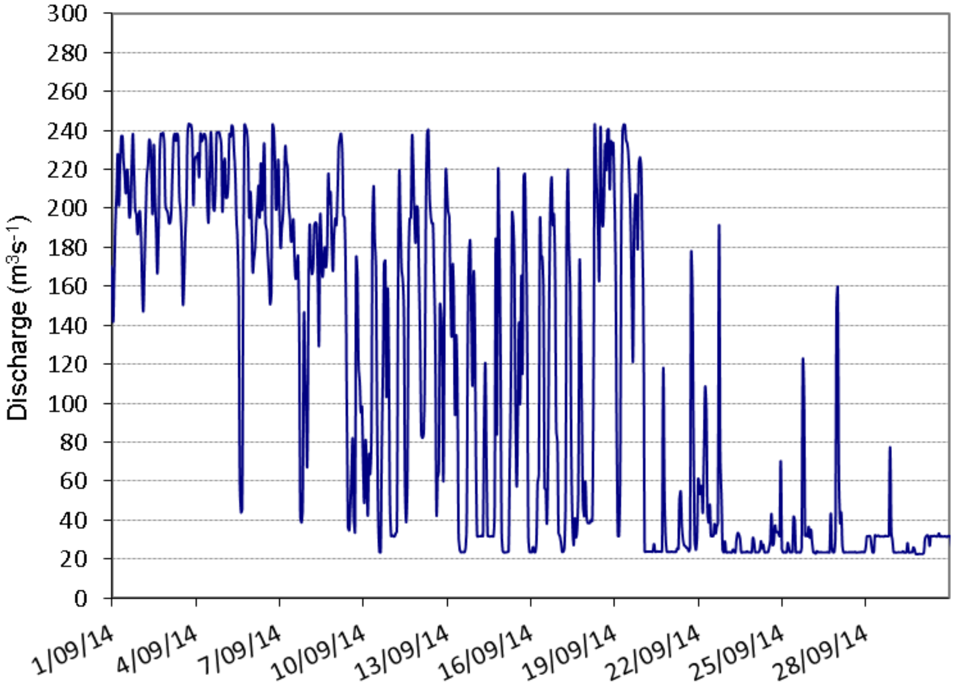

Figure A.3: Gordon Power Station discharge (hourly data) for September 2014.

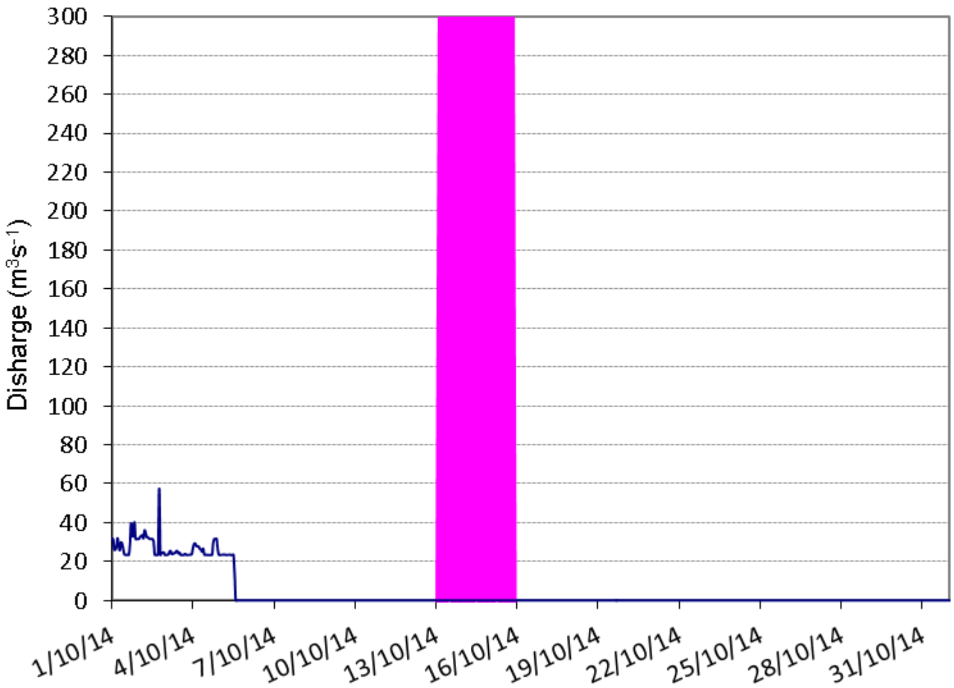

Figure A.4: Gordon Power Station discharge (hourly data) for October 2014. Pink block indicates a monitoring period.

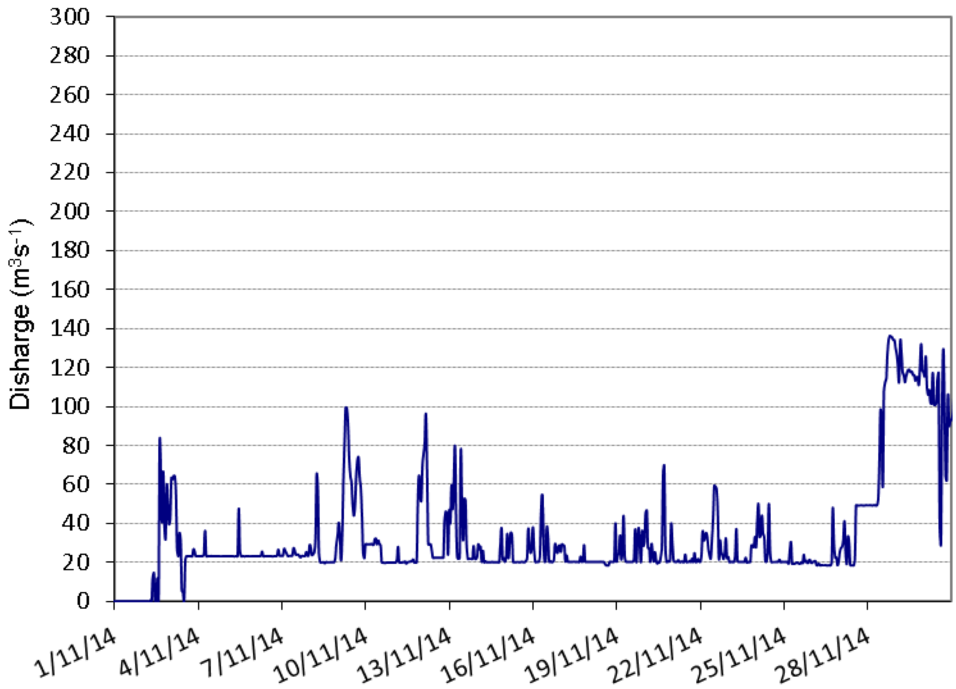

Figure A.5: Gordon Power Station discharge (hourly data) for November 2014.

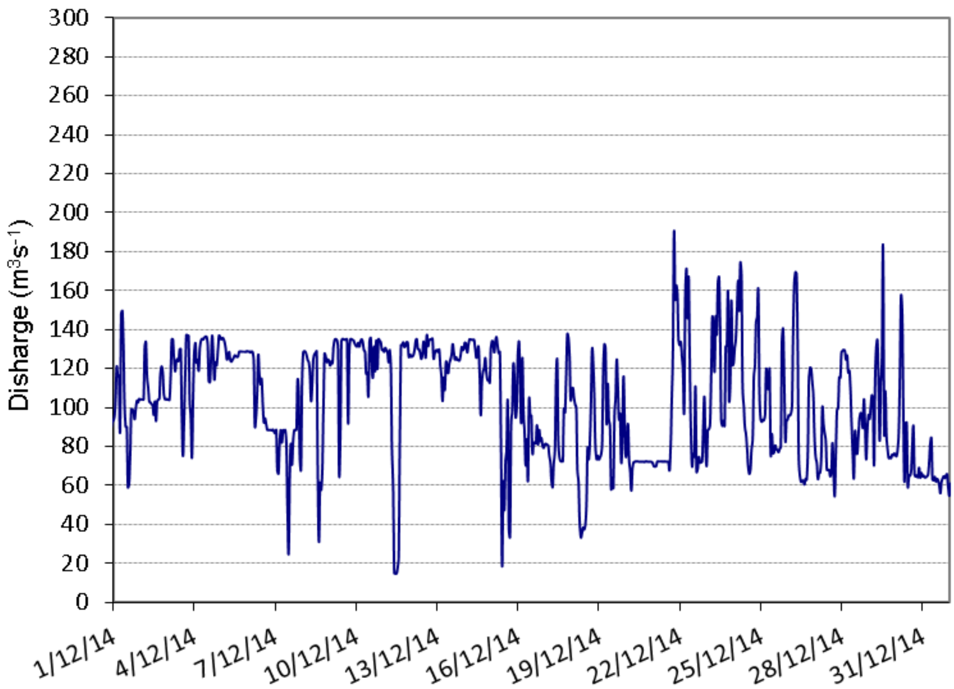

Figure A.6: Gordon Power Station discharge (hourly data) for December 2014.

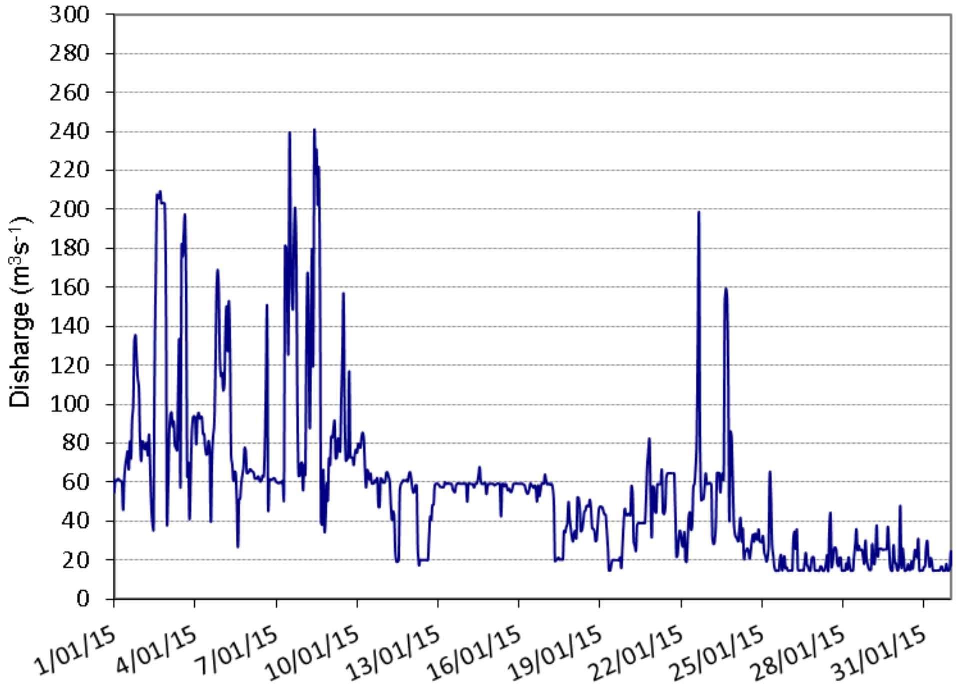

Figure A.7: Gordon Power Station discharge (hourly data) for January 2015.

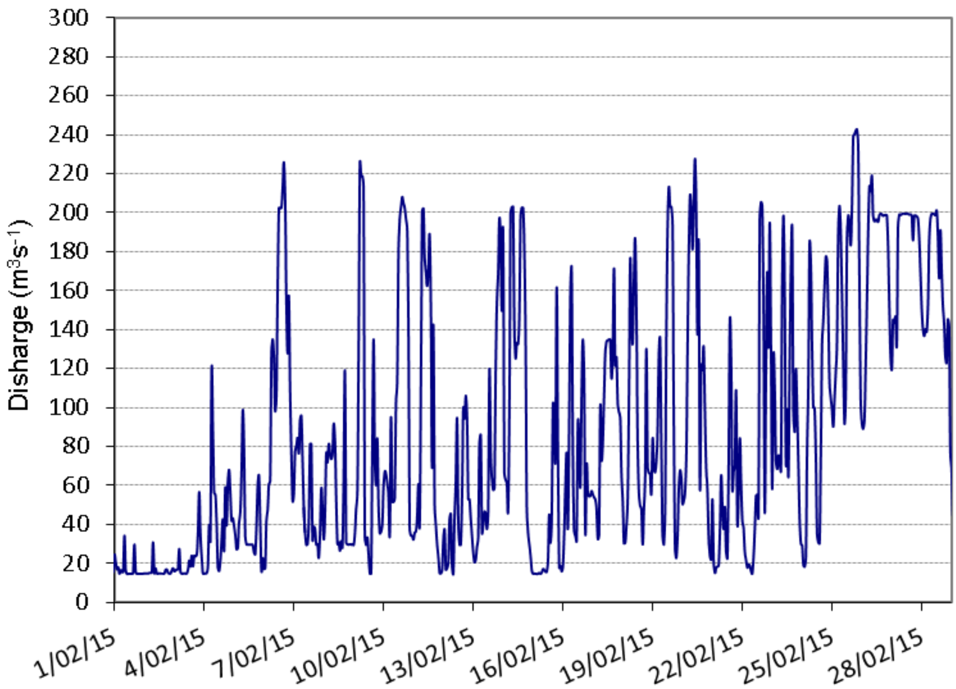

Figure A.8: Gordon Power Station discharge (hourly data) for February 2015.

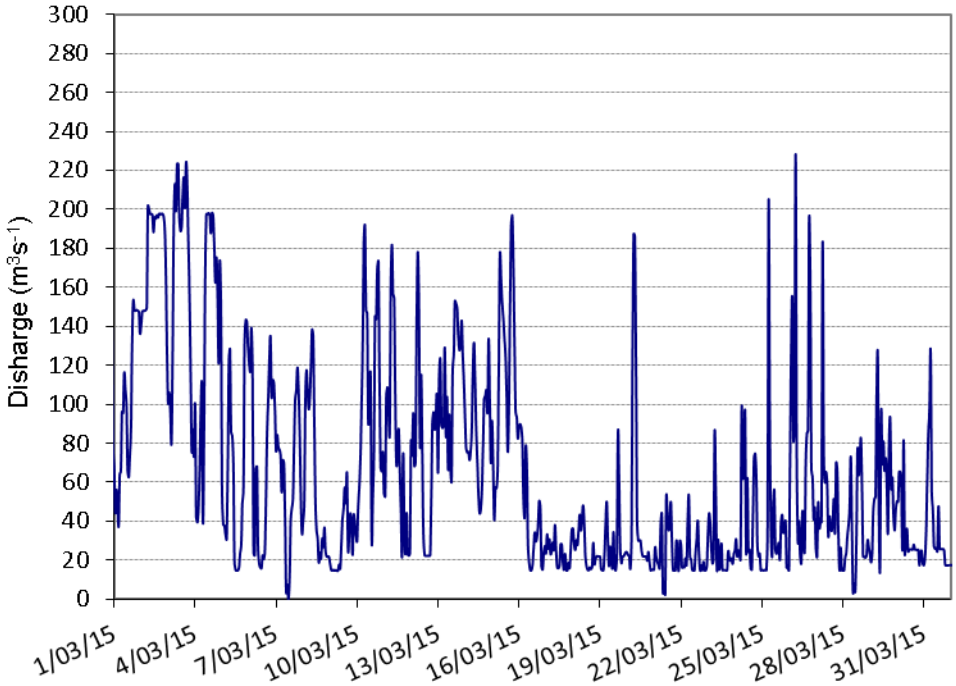

Figure A.9: Gordon Power Station discharge (hourly data) for March 2015.

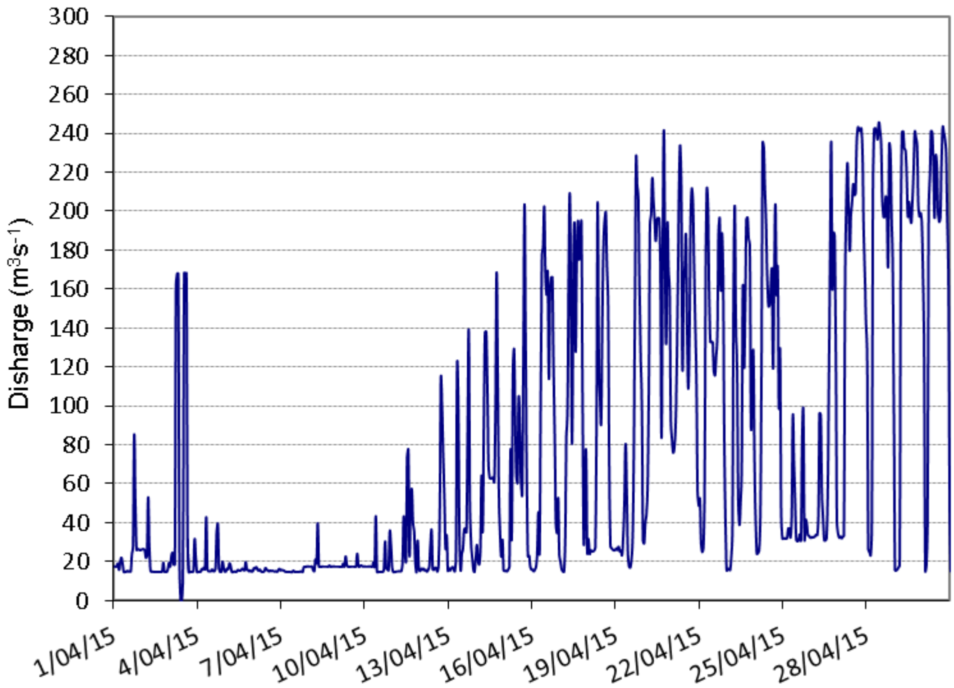

Figure A.10: Gordon Power Station discharge (hourly data) for April 2015.

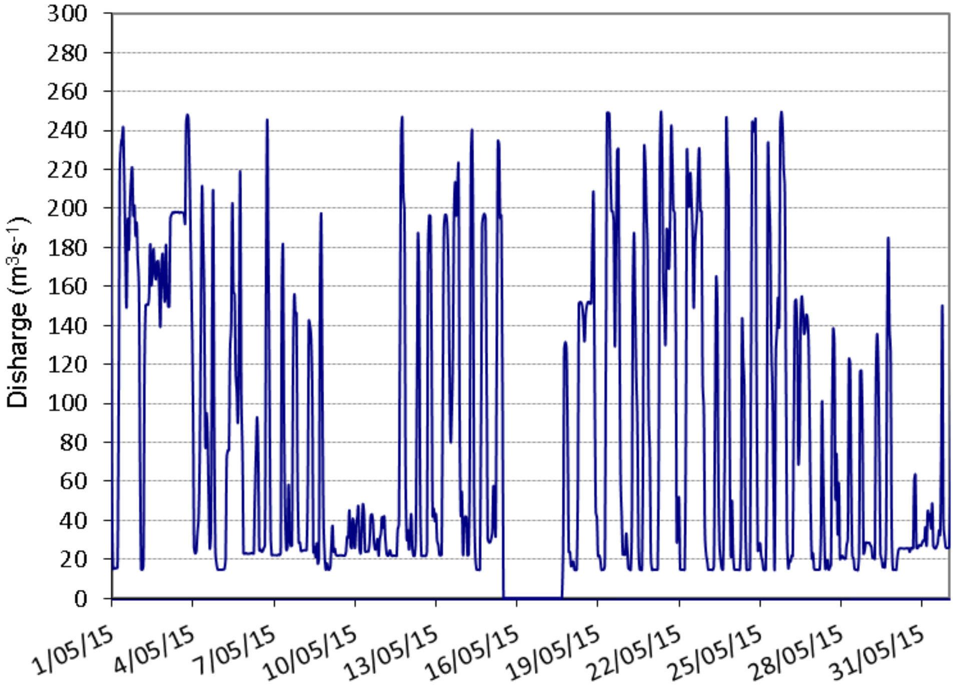

Figure A.11: Gordon Power Station discharge (hourly data) for May 2015.

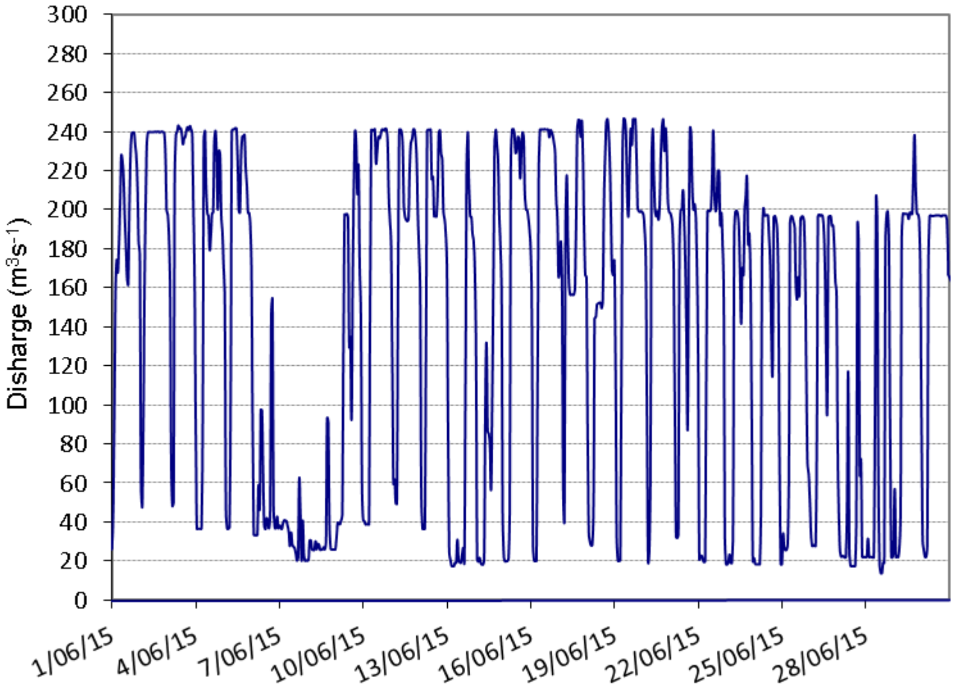

Figure A.12: Gordon Power Station discharge (hourly data) for June 2015.

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B Appendix B: Fast ramp-down events

Table B.1: Fast ramp-down events at Gordon Power Station for 1 July 2014 to 30 June 2015

Event no.	Date	Duration (minutes)	Average Generation reduction rate (MW/min)	Maximum Generation reduction rate (MW/min)	Starting level of piezometer (m)
1	01 Jul 2014	60	-1.77	-2	4.02
2	12 Jul 2014	5	-1.03	-1.03	3.7
3	16 Jul 2014	10	-1.02	-1.03	3.55
4	16 Jul 2014	15	-1.12	-1.14	3.57
5	17 Jul 2014	5	-1.03	-1.03	3.56
6	17 Jul 2014	10	-1.03	-1.05	3.55
7	18 Jul 2014	10	-1.1	-1.11	3.54
8	19 Jul 2014	35	-1.12	-1.18	3.71
9	21 Jul 2014	15	-1.01	-1.02	3.71
10	22 Jul 2014	55	-1.59	-1.72	3.85
11	26 Jul 2014	10	-1.08	-1.1	3.05
12	27 Jul 2014	5	-1.09	-1.09	2.76
13	02 Aug 2014	5	-1	-1	2.97
14	02 Aug 2014	10	-1.02	-1.05	2.97
15	04 Aug 2014	15	-1.03	-1.04	2.89
16	06 Aug 2014	5	-1.07	-1.07	3.06
17	07 Aug 2014	5	-1.25	-1.25	2.99
18	11 Aug 2014	5	-1.03	-1.03	2.93
19	12 Aug 2014	5	-1.03	-1.03	2.76
20	20 Aug 2014	5	-1.02	-1.02	3.08
21	21 Aug 2014	5	-1.01	-1.01	2.88
22	28 Aug 2014	5	-1.06	-1.06	2.95
23	28 Aug 2014	5	-1	-1	2.94
24	29 Aug 2014	15	-1.02	-1.04	3.14
25	31 Aug 2014	5	-1.01	-1.01	3.06
26	06 Sep 2014	10	-1	-1	3.41
27	11 Sep 2014	5	-1.02	-1.02	2.8
28	11 Sep 2014	15	-1.04	-1.05	3.19
29	12 Sep 2014	5	-1.02	-1.02	3.17

Event no.	Date	Duration (minutes)	Average Generation reduction rate (MW/min)	Maximum Generation reduction rate (MW/min)	Starting level of piezometer (m)
30	13 Sep 2014	10	-1.06	-1.06	3.24
31	14 Sep 2014	10	-1.04	-1.05	2.78
32	15 Sep 2014	5	-1.01	-1.01	2.83
33	16 Sep 2014	5	-1.02	-1.02	2.89
34	18 Sep 2014	15	-1.05	-1.08	2.77
35	20 Sep 2014	5	-1.04	-1.04	3
36	20 Sep 2014	5	-1.02	-1.02	3.01
37	28 Feb 2015	5	-1.04	-1.04	2.87
38	28 Apr 2015	5	-1.01	-1.01	2.82
39	30 Apr 2015	5	-1.02	-1.02	3.11
40	01 May 2015	10	-1.04	-1.05	3.04
41	01 May 2015	5	-1	-1	3.04
42	01 May 2015	5	-1.02	-1.02	3.05
43	03 May 2015	5	-1.07	-1.07	3.23
44	03 Jun 2015	5	-1.03	-1.03	3.02
45	11 Jun 2015	5	-1	-1	2.87
46	30 Jun 2015	15	-1.01	-1.03	2.95

C Appendix C: Geomorphology photo monitoring

Appendix C.1. Photos for October 2014 and March 2014 (or earlier where necessary)

P1E: Zone 1, Site 1E, March 2013

P1E: Zone 1, Site 1E, October 2014

P2A: Zone 2, site 2A, March 2013 (no photo from Mar 2014)

Zone 2, Site 2A, October 2014

P2 – 1 Zone 2, Upstream view of cobble bar from site 2A, March 2014

P2 – 1 Zone 2, Upstream view of cobble bar from site 2A, October 2014

P2 - 2, Zone 2, downstream view of cobble bar from site 2A, March 2014

P2 - 2, Zone 2, downstream view of cobble bar from site 2A, October 2014

P2 - 3: Site 2A backwater view upstream March 2014

P2 - 3: Site 2A backwater view upstream October 2014

P2 - 4: Zone 2, view downstream in backwater channel, March 2014 (further downstream – site moved up to pins 6 and 7)

P2 - 4: Zone 2, view downstream in backwater channel, October 2014


P2 - 5, zone 2, Landslip (previously P2 new1), March 2014


P2 - 5, zone 2, Landslip (previously P2 new1), October 2014


P2D: Erosion pin site 2D, March 2014


P2D: Erosion pin site 2D, October 2014


P2E: erosion pin site 2E, March 2014


P2E: Erosion pin site 2E, October 2014


P2 - 6: Left Bank, March 2014


P2 - 6: Left Bank, October 2014


P2 - 7: Left Bank, March 2014 (different angle)


P2 - 7: Left Bank, October 2014


P2 - 8: Left Bank – close up of P2-7, October 2014 (not obtained in March 2014)


P2 - 9: (old P2-2new) Left bank, March 2014


P2 - 9 (old P2-2new) Left Bank, October 2014


P2 - 10: (Old P2-2b) Left Bank, March 2014


P2 - 10 (Old P2-2b) October 2014


P2 - 11: (Old P2-4) Left bank, March 2014


P2 - 11: (Old P2-4) Left bank, October 2014

P2 - 12: Left bank, March 2014

P2 - 12: Left Bank, October 2014

P2 - 13: Left Bank, March 2014

P2 - 13: Left Bank, October 2014

P2 - 14: Left bank, March 2014

P2 - 14: Left Bank, October 2014


P2 - 15: (Old P2-5), Right bank, March 2014


P2 - 15 (Old P2-5), Right bank, October 2014


P2H: Zone 2, site 2H,March 2014


P2H: Zone 2, site 2H, October 2014


P2-16: Left bank, March 2014


P2-16: Left bank, October 2014


P2L: Site 2L, March 2014


P2L: Site 2L, October 2014


P3C: March 2014


P3C: October 2014


P3D: March 2014


P3D: October 2014


P3E: March 2014


P3E: March 2014


P3 – 1: March, 2014


P3 – 1: October 2014


P4 – 1: Landslip at Denison confluence November 2013


P4 – 1: Landslip at Denison confluence October 2014

P4 – 2: Landslip at Denison confluence, October 2013

P4 – 2: Landslip at Denison confluence, October 2014

P4 – 3: (Old P4-1), November 2013

P4 – 3: (Old P4-1), October 2014

P4 – 4, Right bank landslip, October 2013

P4 – 4, Right bank landslip, October 2014


P4D, March 2014


P4D, October 2014


P4E, March 2014


P4E, October 2014


P4H, October 2013


P4H, October 2014

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D Appendix D: Macroinvertebrate data

Appendix D.1. Quantitative macroinvertebrate 'family level' data – spring 2014

Table D.1: Abundances as n per 0.18 m^2 for middle Gordon River and reference sites sampled in spring 2014. (Note: no values are shown for the Maxwell River reference site Ma7, as it was not sampled).

				Gordon River								Franklin River		Denison River		Jane River
Class	**Order**	**Family**	**Sub family**	**Site 75**	**Site 74**	**Site 72**	**Site 69**	**Site 60**	**Site 57**	**Site 48**	**Site 42**	**Site Fr11**	**Site Fr21**	**Site De7**	**Site De35**	**Site Ja7**
Platyhelminthes	Turbellaria			2		1			1			2		1		3
Nematoda					4		1	2	7	1	1		1			1
Mollusca	Gastropoda	Hydrobiidae			2		3					1	1	5		1
Annelida	Oligochaeta			2	55	17	13	20	89	37	10	62	112	37	91	82
Arachnida	Acarina				2							1				
Crustacea	Amphipoda	Paramelitidae							2	1				1	1	
		Neoniphargidae		5	1											
	Isopoda	Janiridae		4	44	11		5	2	2		1			1	1
	Ostracoda															1
Insecta	Plecoptera	Eustheniidae			1			1							3	1
		Austroperlidae					1									
		Gripopterygidae			7	1	1	8	1	1	1	9	3	1	3	16
		Notonemouridae										2	6			
	Ephemeroptera	Leptophlebiidae			2	1	1	11	11	13		15	54	33	133	72
		Baetidae						4				4	4	1	13	27
	Diptera	Chironomidae:	Chironominae		3			3	7	6		2			5	5
		Chironomidae:	Orthocladiinae	1	4			2	3	1		6	1		2	1
		Chironomidae:	Podonominae			4		6	7	2	1	63	47	2	34	1
		Chironomidae:	Tanypodinae									1				
		Chironomidae:	Diamesinae									3				
		Chironomidae:	Aphroteniinae						1					2	2	
		Simuliidae		14	277	61	70	367	27	24	6	220	148	7	200	87
		Tipulidae													1	
		Blephariceridae						1				7	5		6	
		Ceratopogonidae							2			2	2	2	5	1
		Chaoboridae			1											
		Empididae						3								
		Dip. Unid. Pup.				1		7	4	10	1	1	1		1	2
	Trichoptera	Calocidae														6
		Conoesucidae								2		1				
		Glossosomatidae												1		1
		Hydrobiosidae			7	2	2	4	1		1	3	14	3	13	6
		Hydropsychidae			12	1	34	28	6	4						
		Leptoceridae		1					1		1	2	5		9	12
		Philopotamidae										1			1	
		Philorheithridae												1	2	5
		Polycentropodidae											1			
		Trich. Unid. Pup.					1	2	1							
	Coleoptera	ElmidaeA						2		1		2	3	8	21	22
		ElmidaeL					1	2	2	1	1	1	8	59	57	125
		ScirtidaeL										45	10	2	20	8
		PsepheniidaeL														2
			Total abundance	29	422	100	128	478	175	106	23	457	426	166	624	489
			N Taxa (families)	7	15	10	11	19	19	15	9	25	19	17	23	25

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Appendix D.2. Quantitative ‘species level’ data for EPT taxa – spring 2014

Table D.2: Ephemeroptera, Plecoptera and Trichoptera for middle Gordon River and reference sites sampled in spring 2014 (abundances as n per 0.18 m^2). (Note: no values are shown for the Maxwell River reference site Ma7, as it was not sampled).

			Gordon River								Franklin River		Denison River		Jane River
Order	**Family**	**Genus/Species**	**Site 75**	**Site74**	**Site 72**	**Site 69**	**Site 60**	**Site 57**	**Site 48**	**Site 42**	**Site Fr11**	**Site Fr21**	**De7**	**De35**	**Ja7**
Ephemeroptera	Baetidae	*Offadens hickmani					4				4	4	1	13	27
	Leptophlebiidae	Nousia sp. AV5/6				1	5	10	11		13	42	32	129	70
		Nousia sp. AV7			1		5	1	1		1	3		2	1
		Tillyardophlebia sp AV2		2			1		1		1	9	1	2	1
Plecoptera	Eustheniidae	Eusthenia costalis					1								
		Eusthenia spectabilis		1										3	1
	Austroperlidae	Tasmanoperla thalia				1									
	Gripopterygidae	Cardioperla incerta					4				3				2
		Cardioperla media/lobata											1		7
		Dinotoperla serricauda						1		1	2	1		1	
		Leptoperla varia		2		1	2		1						
		Trinotoperla tasmanica		1											
		Trinotoperla zwicki	1	4	1		2				4	2		2	7
	Notonemouridae	Austrocercoides sp									2	6			
Trichoptera	Calocidae	Tamasia variegata													6
	Conoesucidae	Conoesucus fromus							2		1				
	Glossosomatidae	Agapetus sp. AV1											1		1
	Hydrobiosidae	Apsilochorema obliquum										1			
		Ethochorema nesydrion										1		1	
		Moruya opora		4	2	1	3			1	2	2			1
		# Taschorema apobamum						1				1			2
		# Taschorema asmanum					1						1	3	1
		Taschorema ferulum grp (includes all #)		3		1					1	9	2	9	2
	Hydropsychidae	Asmicridea sp. AV1		12	1	34	28	6	4						
	Leptoceridae	Notalina sp.AV1									2				
		Notalina sp.						1		1		5		9	12
	Philopotamidae	Hydrobiosella sp AV10									1			1	
	Philorheithridae	Tasmanthrus sp.											1	2	5
	Polycentropodidae	Paranyctiophylax sp.										1			
		Abundance EPT	1	29	5	39	56	20	20	3	37	87	40	177	146
		N EPT Taxa	1	8	4	6	11	6	6	3	13	14	8	13	16

* = formerly Baetid Genus 2 MVsp3

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Appendix D.3. RBA macroinvertebrate data – spring 2014

Table D.3: Abundances per live picked sample for middle Gordon River and reference sites sampled in spring 2014. (Note: no values are shown for the Maxwell River reference site Ma7, as it was not sampled).

				Gordon River																Franklin River				Denison River				Jane River	
Class	Order	Family	Sub-Family	Site 75		Site 74		Site 72		Site 69		Site 60		Site 57		Site 48		Site 42		Site Fr11		Site Fr21		Site De7		Site De35		Site Ja7	
				1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Platyhelminthes	Turbellaria			3	6									1			2	1	1							2			
Nematoda																				1		1							
Nematomorpha		Gordiidae												1															
Annelida	Oligochaeta				2	2	9	16	22	25	16	16	24	27	26	12	14	22	69	7	5	40	16	14	5	21	19	12	15
Arachnida	Acarina																										1		
Crustacea	Amphipoda	Paramelitidae											2	5	4	3	1	2	1		4					1			
		Paracalliopidae															1		1										
		Neoniphargidae		6	5	1	2			1	1																		
	Isopoda	Janiridae		18	23			1	3	2					1														
		Phreatoicidea					1			2	1																		
Insecta	Plecoptera	Eustheniidae		2			1			1	1		1	5		1	1	1	1			1				7	3		2
		Austroperlidae																										1	
		Gripopterygidae			2	11	7	2	2			5	11	2		3	4	1	3	14	7	4	10	3		16	15	7	2
		Notonemouridae						2						1	1			1											
	Ephemeroptera	Leptophlebiidae		4	2	1		9	5	11	8	34	30	46	30	32	27	10	9	70	69	109	72	85	97	82	47	79	86
		Baetidae										2	1	1	4		2			25	10	10	6		3	12	8	5	9
	Diptera	Chironomidae:	Chironominae				1			1				5	1	1	2	3	1		2					2	2		
		Chironomidae:	Orthocladiinae	1		1		1		1			1	5	1		2	4		11	10						3		
		Chironomidae:	Podonominae	2	2	1		7	4	1		16	11	32	64	21	25	4	5	44	39	72	55	23	18	17	44	24	10
		Chironomidae:	Tanypodinae															1					1						
		Chironomidae:	Diamesinae			1														1									
		Simuliidae		54	61	66	84	115	135	84	96	30	23	13	7	22	35	13	14	52	29	49	27	10	11	24	24	15	15
		Tipulidae							1			1		1	5	1		4	5						1	6	2	2	
		Blephariceridae												2						1	1								1
		Ceratopogonidae																2	1			11	2					1	
		Chaoboridae		4	2																								
		Empididae																									1		
		Dip. Unid. Pup.							1					2	1	3	1	2	3							1			
	Trichoptera	Calocidae																								5	3		
		Conoesucidae		1															1								1		
		Glossosomatidae																		1									
		Hydrobiosidae		49	56	16	18	23	10	6	23	21	25	9	1	21	18	1	6	25	26	15	25	11	11	25	16	11	16
		Hydropsychidae				30	25	4	1	9	24	12	8	3		6	7	1											
		Leptoceridae										1			1		2	1		1	1						16		1
		Philorheithridae													2	1				3	4	1		1			6		
		Trich. Unid. Pup.										11	2	3		1													
	Coleoptera	ElmidaeA						1				1		2		2	1		3	5	4	1		7	4	32	36	2	3
		ElmidaeL													5					1	2		1	1	1	7	38	1	2
		ScirtidaeL															1	1		20	28	43		1	6		13	2	1
		PsepheniidaeL																1								1	3	1	
			N Taxa	11	10	10	9	11	10	12	8	12	12	20	16	15	18	20	16	17	16	13	10	10	10	17	21	14	13

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Appendix D.4. Trigger value metrics

Table D-4: Values of all metrics for each site sampled in spring 2014 (Note: no values are shown for the Maxwell River reference site Ma7).

			Spring 2013								
			Community Structure		Community Composition		Taxonomic richness		Ecologically significant species		Biomass / productivity
River	Site code	Old code	Bray Curtis (abundance)	O/Erk	Bray Curtis (pres/abs data)	O/Epa	N Taxa (fam)	N EPT species	Propn abundance EPT	Abundance EPT	Total abundance
Gordon											
	75	G4	5.81	0.47	11.99	0.38	7	1	0.034	1	29
	74	G4a	26.17	0.49	38.12	0.48	15	8	0.069	29	422
	72	G5	15.53	0.57	26.65	0.58	10	4	0.050	5	100
	69	G6	15.58	0.50	31.27	0.49	11	6	0.313	40	128
	60	G9	39.76	1.03	54.25	0.71	19	11	0.121	58	478
	57	G10	32.29	1.03	37.67	1.05	19	6	0.120	21	175
	48	G11B	32.19	0.94	34.04	1.00	15	6	0.189	20	106
	42	G15	12.14	0.97	23.49	1.09	9	3	0.130	3	23
Reference											
Franklin	Fr11	G19	48.55	1.02	58.78	1.01	25	13	0.081	37	457
	Fr21	G20	57.20	0.79	62.81	0.71	19	14	0.204	87	426
Denison	De7	G21	47.89	0.64	53.18	0.68	17	8	0.241	40	166
	De35	D1	57.56	1.12	67.63	1.11	23	13	0.284	177	624
Jane	Ja7	J1	57.63	0.79	68.10	0.87	25	16	0.299	146	489