BASSLINK INTEGRATED IMPACT ASSESSMENT STATEMENT

POTENTIAL EFFECTS OF CHANGES TO HYDRO POWER GENERATION

SUMMARY REPORT

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EXECUTIVE SUMMARY

Hydro Tasmania has undertaken extensive investigations into the potential changes to generating system operations due to a Basslink cable, and the environmental implications of these changes. Basslink would connect the Tasmanian electricity system to the National Electricity Market, and change the way the Hydro Tasmania system is operated.

Results of analyses using a predictive model known as TEMSIM (Tasmanian Electricity Market Simulation Model) showed that only three power stations in the State had significantly different patterns of operation with Basslink. These are the Gordon Power Station in the southwest of the State, the Poatina Power Station in the north-central part of the State, and the John Butters Power Station in the middle of the West Coast.

In general, Basslink is projected to increase the on-off operation of the Gordon, Poatina and John Butters power stations throughout the full range of discharges, result in more winter discharge than at present, and increase the occurrence of high power station discharges (although this is over-estimated due to a model bias). Increased occurrence of weekend shutdowns for Gordon and Poatina is also indicated by the model runs. Variability between years in patterns of power station operation is likely to be reduced. Changes are most significant for the Gordon and Poatina power stations, and less so for the John Butters Power Station. No significant changes are indicated by the modelled results for any of the lakes in the Hydro Tasmania generating system, and existing lake level agreements will continue with or without the commissioning of Basslink.

Environmental investigations on the Gordon River encompassed hydrology, water quality, fluvial geomorphology, karst, riparian vegetation, macroinvertebrates and aquatic mammals, fish, terrestrial fauna, cave biota, meromictic lakes, cultural heritage, public use and World Heritage Area values. Environmental impacts with the Basslink development, in the absence of the substantial mitigation measures to which Hydro Tasmania commits, were indicated from the investigations to relate to four areas of study:

- **Fluvial Geomorphology:** Basslink is predicted to change the geomorphic processes controlling stability of the Gordon River banks relative to the present processes. Notably, this will be an increase in the probabilities of scour (this is believed to be over-estimated because of the TEMSIM model bias of increased full capacity power station discharge), and an alteration to conditions leading to bank saturation, thus modifying seepage erosion processes. The average annual number of drawdown events increases significantly with Basslink, which may lead to an increase in the occurrence of seepage-induced erosion, but probably not an increase in severity because banks are less saturated. Basslink changes are anticipated to be limited to adjustments of alluvial bank profiles, but no change to river planform compared to existing effects of flow regulation.

- **Riparian Vegetation:** Basslink is predicted to accelerate present rates of loss of riparian vegetation communities. As part of this, Basslink is projected to cause migration of the existing vertical zonation in the river banks up the bank (also believed to be over-estimated because of the TEMSIM model bias). The majority of the riparian vegetation, particularly upstream of the Splits to a height of 2.5 m above low water mark on the river banks, is anticipated to die and not be replaced in the long-term under existing conditions, and this would not change with Basslink.

- **Aquatic Macroinvertebrates:** Basslink is predicted to alter the community composition of macroinvertebrates in the Middle Gordon River, and further reduce diversity and abundance both upstream and downstream of the Denison River confluence. Follow-on effects may be seen in platypus and native water rats which rely on macroinvertebrates for their food supplies.

- **Fish:** Basslink is predicted to result in reduced availability of fish habitat within Middle Gordon River, and reduced food supplies through impacts on macroinvertebrates may lead to further reduced populations.

Aspects of the Basslink operating regime mitigate against some existing environmental impacts. These include:

- **Water Quality:** Basslink holds Lake Gordon somewhat lower in its operating range compared to historical operations, which reduces the risk of low dissolved oxygen and seasonally cooler water being drawn into the power station intake; and

- **Fish and Platypus Dispersal:** The increased occurrence of short-term and weekend power station shutdowns provides more opportunity for fish passage and platypus dispersal in the Middle Gordon River.

An assessment of Basslink implications on the values for which the Tasmanian Wilderness World Heritage Area was declared concluded that Basslink does not substantially degrade WHA values, and in fact may provide some opportunity to enhance values with the substantial mitigation measures to which Hydro Tasmania commits.

Environmental investigations downstream of the Poatina Power Station encompassed hydrology, water quality, fluvial geomorphology, instream biota, terrestrial biota, cultural heritage, and landowner issues. Environmental impacts with the Basslink development, in the absence of the substantial mitigation measures to which Hydro Tasmania commits, were indicated from the investigations to relate to four areas of study:

- **Water Quality:** Basslink is anticipated to cause rivers downstream of Poatina to experience slightly lower summer temperatures, and rapid fluctuations in water quality parameters. Salinity along Brumbys Creek banks will decrease if driven by inundation, but increase if driven by fluctuations.

- **Fluvial Geomorphology:** Basslink is predicted to cause a change in existing channel degradation processes in Brumbys Creek (from seepage-induced draw-down failures to scour of toe and bed leading to slumping). In the clay soils of the Macquarie River downstream of Brumbys Creek, increase in wetting-drying cycles in upper portion of banks will increase definition of a step in this part of the bank. In sandier soils in the Macquarie and South Esk rivers, Basslink presents some potential for increase in scour, undercutting and small-scale failures (again, these impacts may be over-estimated by TEMSIM model bias).

- **Instream Biota:** Basslink is predicted to increase stresses on macrophytes (aquatic plants) in the three existing Brumbys Creek weir ponds downstream of the tailrace (see Map 4), to impact on weir pool ecosystems and fishery productivity, and increase stresses on macroinvertebrates and fish in the main channel. Frequent dewatering periods could possibly impact on trout recruitment. Increased occurrence of maximum discharges would also stress the instream biota (believed to be over-estimated). There may also be impacts for platypus but these are unlikely to affect the population as a whole.

- **Socio-Economic Issues:** Basslink is predicted to cause problems for water abstraction by landowners by affecting pump-set ups with the fluctuating flows over the whole power station range and increased power station shutdowns. The risks of stock strandings are increased due to the frequent on-off of the power station. Increased work stresses associated with fluctuating water levels may be an issue for Sevrup Pty. Ltd. Adverse impacts on the recreational trout fishery in

Brumbys Creek may arise due to projected impacts on macroinvertebrate food supplies. Increased risks to public safety may be an issue with increased fluctuations in water levels.

Basslink in the absence of mitigation measures is anticipated to improve flow-through, and hence water quality, in Brumbys Creek weir ponds with Poatina off for shorter durations compared to existing conditions.

Environmental investigations downstream of the John Butters Power Station encompassed hydrology, water quality, fluvial geomorphology, instream biota, cultural heritage, public use, and a water quality assessment of Macquarie Harbour. Although subtle changes due to Basslink are identified in the investigations undertaken for downstream John Butters Power Station, none of the potential changes are believed to create significant management issues. The areas of impact appear to be only to the water quality and geomorphology, and these changes are speculative and fairly minor in proportion to the magnitude of existing environmental issues related to mining impacts:

- **Water Quality:** Basslink is predicted to result in a slight increase in the fluctuations affecting dilution and cold water inputs, and a potential increase in frequency of high concentration metal plumes (originating from the mine lease site) due to more frequent operation of the power station.

- **Fluvial Geomorphology:** Basslink is predicted to result in a possible increase in removal rate of mine tailings in river bed due to increased scour, and increased occurrence of small turbid plumes, both due to the power station turning on more often.

Metal-laden and turbid plumes, related to drainage from the Mount Lyell mining lease and tailings storages in the King River, are a regular feature of the King River downstream of the Queen River. An increased number of short power station shutdowns under Basslink lessens the severity of these occurrences, as under present conditions the greatest concern arises with long power station shutdowns which increase the metal concentrations in these plumes. Consequently, no mitigation measures are proposed for Basslink changes to the John Butters Power Station.

Basslink results in a positive outcome for Macquarie Harbour. King and Gordon freshwater inflows are more coincidental (similar to natural proportions between the two rivers), which lessens the probabilities of metal-laden King River plumes extending far into the harbour. Modelling work assessing Basslink changes to Macquarie Harbour showed no significant changes to either Macquarie Harbour circulation patterns or pollution risk under Basslink operating regimes for the John Butters and Gordon power stations. Strong summer Gordon River flows which are beneficial for the aquaculture industry are maintained under Basslink. As a consequence, Basslink poses no issues for the aquaculture industry.

Hydro Tasmania is committed to implementation of the following mitigation measures if the Basslink project is approved:

- Maintenance of a minimum environmental flow in the Gordon River of 19 m^3/s between December-May, and 38 m^3/s between June-November, measured just upstream of the Denison River. Minimum flow targets will be lowered proportionately if inflows to Lake Gordon are lower, because the flow targets of 19 and 38 m^3/s are based on average pre-dam minimum flows, and the river under pre-dam conditions would experience flows lower than these during dry years. This minimum flow will be phased in over a period of years, to allow adequate monitoring of environmental benefit and understanding of environmental response to progressively increasing minimum environmental flows. A minimum environmental flow will improve conditions for the instream macroinvertebrate biota, by ensuring watering of the ‘mid-tidal’ zone and inundation of marginal snag habitats. It would also result in increased habitat for fish, improved food supply (macroinvertebrates) for fish and platypus, and be beneficial for the fluvial geomorphology by lessening scour of the bank toe and reduce phreatic surface gradient out of the banks. This measure is costed at $1-2 million in losses per annum to Hydro Tasmania.

- Implementation of a mitigation measure to minimise seepage-induced erosion of the Middle Gordon riverbanks, such as a ramp-down or step-down rule for the Gordon Power Station. An example of a potential power station operating rule which is receiving close consideration is the '210-150' rule, which requires the power station to step down from discharges greater than 210 m^3/s to 150 m^3/s for one hour before shutting down, with the aim of allowing drainage of the upper portion of the bank and reducing draw-down rates. Hydro Tasmania is committed to an experimental approach to development of a mitigation measure that is both environmentally and economically sustainable. To support this assessment, Hydro Tasmania is committed to installation of robust long-term piezometer sites and development of a riverbank saturation-phreatic surface gradient model to test seepage response to different scenarios.
- Construction of a 1.5 Mm^3 capacity re-regulation weir to create an environmental control pond downstream of the Poatina tailrace. This pond would dampen 60% of the downstream flow fluctuations, and maintain a higher minimum water level in the weir ponds, thus improving present and Basslink environmental concerns with water quality fluctuations, bank erosion, stresses on instream biota, and problems for landowners with pumping arrangements and stock stranding. The environmental control pond is intended to be operational at the time of commencement of Basslink operations. This measure is costed at $400,000 per annum on an annualised basis.

Because of the absence of significant management issues, no mitigation options in relation to Basslink are required for downstream of the John Butters Power Station.

Hydro Tasmania is committed to a review of the effectiveness of these mitigation measures, and future trends in environmental parameters in the Basslink-affected rivers, via a substantial Basslink monitoring program. This program would be additional to Hydro Tasmania's existing Waterway Health Monitoring Program. The Basslink program is focussed on the waterways downstream of the Gordon, Poatina and John Butters power stations, and is costed at $333,000 per annum. The Basslink monitoring program commences three years prior to the Basslink development, with the first year being the 2000 investigation year, and goes for up to six years post-Basslink development.

Regardless of the Basslink development occurring or not occurring, Hydro Tasmania is committed to compliance with its Aquatic Environmental Policy and ongoing implementation of its existing Aquatic Environment Program. This program includes major initiatives such as the Water Management Reviews and also a long-term Waterway Health Monitoring Program. Specific initiatives already occurring under the Aquatic Environment Program are continued assessment of the Gordon meromictic lakes, and evaluation of the Poatina Power Station flood rules.

Water management commitments can be incorporated into the Hydro Tasmania Water Licence and so be regulated under the Tasmanian *Water Management Act* 1999.

The Basslink project accompanied by the Hydro Tasmania commitments presents an opportunity to improve environmental management and sustainability of the Tasmanian freshwater resources, because it provides the financial framework for Hydro Tasmania to implement major riverine enhancement measures for the Gordon River and downstream Poatina Power Station. Whilst by definition "natural" conditions can never be achieved in a regulated river system, these measures represent the best practicable approach to improving environmental issues of concern, both present and Basslink issues, in the respective waterways.

The effectiveness of these measures will be closely documented through a substantial Basslink monitoring program which in itself is a major benefit of Basslink. Hydro Tasmania is committed to an adaptive management approach in responding to information obtained through the monitoring program, so that mitigation measures can be re-assessed and fine-tuned over time to ensure that they are environmentally and economically sustainable.

The proposed mitigative measures are in keeping with Hydro Tasmania’s environmental policy and growing list of environmental achievements. They further demonstrate Hydro Tasmania’s commitment to the sustainable management of Tasmania’s water resources.

ACKNOWLEDGEMENTS

This report has been prepared as part of Hydro Tasmania's Basslink Project. The investigations summarised in this report and presented in detail in the 29 attached appendices are the product of a multi-year effort involving numerous Hydro Tasmania staff and external consultants.

The environmental assessment of potential changes to Tasmanian water management arising from Basslink has been co-ordinated by an internal Hydro Tasmania team, involving Andrew Scanlon (Project Director), Helen Locher (Project Manager), Mick Howland (Co-ordinator Gordon River Investigations), Jacqueline Griggs (Report Production Co-ordinator), Stephen Bresnehan (Mapping, GIS & Presentation Support), David Blühdorn (Monitoring Programs), Anita Wild (GIS Analysis), Kate Hoyle (Editing and Report Production Support) and Donna Porter (Administration Support). Mick Howland and Jackie Griggs, in particular, have played a considerable role in co-ordination, planning and review of the investigation and reporting stages of this project.

Numerous other staff from different groups in Hydro Tasmania contributed to the project including:

- *Environmental Services*: Helga Grant and Mel Ellis (preparation of the King River Cultural Heritage Report).
- *Basslink Project Office*: Steve Halliday, Alastair Christie, David Hamilton (provision of information and review)
- *Survey and Geographic Information*: Hayden Dwyer, Hayden Foley, Graham Humphries, Keith Stove, Steven Thomas, Chris Spotswood, Harley Winram (King River cross-section and channel surveys, King River and Gordon River aerial photography, comparative analyses of aerial photos).
- *Resource Analysis Group (System Modelling)*: Mike Connarty, Gregg Barker, Roger Parkyn, Fleur Yaxley, Rob Grant (TEMSIM model runs and analysis, system analysis, assessment of mitigation options).
- *Resource Analysis Group (Hydrology)*: Fiona McConachy, Lennie Palmer, Kirsten Adams, Crispin Smythe, Holly Taylor, Jayson Peterson and Wes Jeffries (preparation of hydrology appendices and considerable additional hydrological analysis).
- *Resource Monitoring Group*: Stephen Buckland, Anthony Buckland, Peter Harding, Mark Johnston, Cameron McCarthy, Ben Martin, Anthony Mountain, Robert Robinson, Lukas Salkeld, Wayne Soutter and Jason Sulzbergen (installation, interrogation and maintenance of hydrological and water quality monitoring equipment, and development and testing of prototype instrumentation).
- *Civil Engineering*: John Davies, Bram Knoop (bank stability modelling, mitigation option assessment)
- *Electrical and Mechanical Engineering*: Martin Grose, Peter Wiehe, Dave Pollington (mitigation option assessment)
- *Production*: Stephen Stolp, Simon Krohn, Greg Carson (mitigation option assessment, project support and review)

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- Dr. Peter Davies and staff (Freshwater Systems);
- Dr. Lois Koehnken (Technical Advice on Water);
- Dr. Bruce Abernethy (Sinclair Knight-Merz);
- Dr. Peter Tyler and Dr. Peter Kew (Deakin University);

- Dr. Neil Davidson and Andy Gibson (Co-operative Research Centre for Sustainable Production Forestry);
- Dr. Lorne Kriwoken (University of Tasmania);
- Dr. Ian Rutherfurd and Mr. John Styles (CRC for Catchment Hydrology, University of Melbourne);
- Dr. David Dunkerley (Monash University);
- Chris Thompson and Bill Chilvers (Serve-Ag);
- Dr. Colin Terry (Colin Terry & Associates);
- Jenny Deakin, Jeff Butt and Jol Desmarchelier (independent consultants);
- Dr. Niall Doran, Dr. Alistair Richardson and Suzette Wood (University of Tasmania);
- Anne McConnell(Cultural Heritage Management, Archaeology and Quaternary Geoscience);
- Steve Stanton and Lindy Scripps (independent consultants);
- Dr. Clifford Hearn (University College of UNSW, ADFA);
- Dave Andrews and associates (Inland Fisheries Services);
- Nick Poltock (Nick Poltock Field Exploration).

Two honours students collected sediment samples and undertook particle size analyses and additional sediment analyses in support of the Gordon and Poatina geomorphology assessments - Mat Brook (supervised by Dr. Kate Brown, University of Tasmania, Hobart campus) and Amanda Locatelli (supervised by Dr. Joanna Ellison, University of Tasmania, Launceston campus).

The Gordon River studies involved major outages of the Gordon Power Station and helicopter assisted transport. Logistical preparations were extensive, and were considerably assisted by the Hydro Tasmania Gordon Power Station personnel, Hydro Tasmania System Control, the Hydro Tasmania Water Management and Generation Supply group, Helicopter Resources, and the Lake Pedder Chalet.

Feedback on the scope and outcomes of these investigations was provided by the Department of Primary Industries, Water and the Environment’s Basslink working group, led by Tony Dell, and comprising members from Assessments, Environmental Policy, Environmental Planning and Scientific Services, Nature Conservation, Threatened Species, Inland Fisheries Service.

This summary report for the Hydro Tasmania Basslink investigations benefited greatly from the review by and discussions with of all the researchers involved, and review and input by numerous Hydro Tasmania staff and NSR Environmental Consultants Pty Ltd. Specific acknowledgement goes to Stephen Bresnehan for his considerable assistance with map/graphics production and writing of specific sections, David Blühdorn for the sections on monitoring and further studies, and Kate Hoyle for formatting.

The investigations of potential environmental impacts of Basslink changes to hydro water management benefited greatly from the endorsement by Hydro Tasmania of the scope and depth of the investigations, the emphasis on quality, and the provision of considerable resources to the project. Hydro Tasmania committed $2.5 million to the environmental investigations summarised in this report.

The complete list of appendices to this report, and their authors and affiliations, is as follows:

App.1 Scoping Report: Basslink Aquatic Environmental Project – Environmental Services, Hydro Consulting

App.2 Gordon River Hydrology Assessment – F. McConachy, L. Palmer & J. Peterson (Hydro Tasmania Resource Analysis)

App.3 Gordon River Water Quality Assessment – L. Koehnken (Technical Advice on Water)

App.4 Gordon River Fluvial Geomorphology Assessment - L. Koehnken (Technical Advice on Water), H. Locher (Hydro Tasmania Environmental Services), & I. Rutherfurd (CRC for Catchment Hydrology, U. Melbourne)

App.5 Gordon River Karst Assessment – J. Deakin, J. Butt, & J. Desmarchelier

App.6 Gordon River Riparian Vegetation Assessment – N. Davidson & A. Gibbons (CRC for Temperate Hardwood Forestry)

App.7 Gordon River Macroinvertebrate and Aquatic Mammal Assessment – P. Davies & L. Cook (Freshwater Systems)

App.8 Gordon River Fish Assessment – M. Howland (Hydro Tasmania Environmental Services), P. Davies (Freshwater Systems), & D. Andrews (Inland Fisheries Service, Tasmania)

App.9 Gordon River Terrestrial Fauna Assessment – J. Griggs (Hydro Tasmania Environmental Services)

App.10 Gordon River Cave Flora and Fauna Assessment – N. Doran, A. Richardson and & S. Woods (U. Tasmania)

App.11 Gordon River Meromictic Lakes Assessment – P. Tyler (Deakin U.), C. Terry (Colin Terry & Associates), & M. Howland (Hydro Tasmania Environmental Services)

App.12 Gordon River Cultural Heritage Assessment – A. McConnell (Cultural Heritage Management, Archaeology and Quaternary Geoscience), S. Stanton (Aboriginal Heritage Consultant) & L. Scripps (Consultant Historian)

App.13 Gordon River Public Use Assessment – L. Kriwoken (U. Tasmania)

App.14 Gordon River World Heritage Area Values Assessment – L. Kriwoken (U. Tasmania)

App.15 Downstream Poatina Hydrology Assessment – H. Taylor, K. Adams & J. Peterson (Hydro Tasmania Resource Analysis)

App.16 Downstream Poatina Water Quality Assessment – L. Koehnken (Technical Advice on Water)

App.17 Downstream Poatina Geomorphology Assessment – B. Abernethy (Sinclair Knight-Merz) & S. Bresnehan (Hydro Tasmania Environmental Services)

App.18 Downstream Poatina Instream Biota Assessment – P. Davies & L. Cook (Freshwater Systems)

App.19 Downstream Poatina Terrestrial Biota Assessment – J. Griggs & S. Bresnehan (Hydro Tasmania Environmental Services)

App.20 Downstream Poatina Cultural Heritage Assessment – A. McConnell (Cultural Heritage Management, Archaeology and Quaternary Geoscience), S. Stanton (Aboriginal Heritage Consultant) & L. Scripps (Consultant Historian)

App.21 Downstream Poatina Landowner Issues Assessment – C. Thompson & B. Chilvers (Serve-Ag, Tasmania)

App.22 King River Hydrology Assessment – L. Palmer & H. Taylor (Hydro Tasmania Resource Analysis)

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GLOSSARY AND LIST OF ACRONYMS

The following is a list of terms and acronyms used in this report.

Term	Definition
Active Storage	Storage volume situated above the normal minimum operating level of a lake, drawn from to generate power.
Acid Drainage (AD)	Acidified and metal-rich waters draining from mining sites in sulphide-rich deposits
ASL	Altitude above Sea Level
AUSRIVAS protocol	Australian River Assessment Scheme
BDB	Basslink Development Board
CPUE	Catch Per Unit Effort, a measure of fishing success.
Cumec	A measure of water flow; cubic metres per second. Also written as m^3/s.
DPIWE	Department of Primary Industries, Water and the Environment.
EOL	Economic Operating Level - The monthly or seasonal level above which the reservoir should be maintained to maximise energy potential.
Efficient Load	Power station energy generation at maximum efficiency
Following Stations	Generally run-of-river stations, downstream stations which operate at same time as immediately upstream stations, utilising water discharged from the immediately upstream station.
Full Gate	Maximum power generation from a given power station
FSL	Full Supply Level - The maximum level at which water can be stored indefinitely, equal to the crest level of the spillway.
FST Hemispheres	A device used in the measurement of turbidity.
GTSPOT	The rare and threatened species database maintained by the Department of Primary Industries, Water and Environment.
Head Storage	Usually a medium-sized storage, situated at the top of ‘run-of-river’ systems defined below.
HWM	High Water Mark
IFIM	Instream Flow Incremental Methodology
JAP	Joint Advisory Panel
LLA	Lake level agreement
LTMC	Long-Term Marginal Cost
LWD	Large Woody Debris
LWM	Low Water Mark
Major Storage	Largest storages with inter-annual variation in major storage capacity; ie Lake Gordon, Great Lake
Medium-Sized Storage	Large storages with inter-seasonal variation in major storage capacity; e.g. Lakes Burbury and Rowallan.
Meromictic lake	A rare type of lake characterised by two stable layers- an upper oxygenated freshwater layer and a lower deoxygenated saline layer.

MOL	Minimum Operating Level - Minimum level at which power can be generated.
NEM	National Electricity Market
NMOL	Normal Minimum Operating Level - The lowest level of storage at which all the machines in the power station can be simultaneously and continuously operated at full gate opening.
NTU	A measure of turbidity
O/E	Observed *versus* Expected; a measure of biological community health which may be based on presence/absence (O/E_{pa}) or abundance (O/E_{ra})
PEV	Protected Environmental Value
Phreatic Surface Gradient	‘Phreatic surface’ refers to water level of groundwater in the riverbanks, and where combined with ‘gradient’ refers to the drainage slope of the groundwater out of the riverbanks.
Piezometer	An instrument used for measuring the pressure head of liquids, used here to measure the groundwater level in the riverbanks.
Plimsoll line	A noticeable high water mark on a riverbank
PS	Power Station
RAP Sampling	‘Rapid Assessment Protocol’ for macroinvertebrate sampling
RIVPACS	River InVertebrate Prediction and Classification Scheme
RPDC	Resource Planning and Development Commission
Run-of-River Storage	Small storages with limited variation in level, usually in a sequence, and responding largely to inflows (river flows and rainfall); e.g. in Derwent, Pieman and Forth systems
SMP	System Marginal Price
SYSOP	The current Hydro operating system simulation model
TEIS	Total Energy in Storage
TEMSIM	Tasmanian Electricity Market Simulation model
TWWHA	Tasmanian Wilderness World Heritage Area
VoLL	Value of Lost Load
WHMP	Hydro Tasmania’s Waterway Health Monitoring Program
WMP	Water Management Plan
WMR	Water Management Review
WQG	Water Quality Guideline
WQO	Water Quality Objective
WUA	Weighted Useable Area, a measure of habitat availability.

1 INTRODUCTION

Section 1 begins with the purpose of this report (Section 1.1). Section 1.2 shows how this report provides information which meets specific requirements of the Integrated Impact Assessment Statement for Basslink. The water management responsibilities of Hydro Tasmania, which provide a context for the Hydro Tasmania Basslink investigations and response, are described in Section 1.3. Section 1.4 outlines the approach to the Hydro Tasmania Basslink investigations, and Section 1.5 provides an outline of the structure of this report.

1.1 Purpose of this Report

Basslink is a proposed undersea power cable across Bass Strait that will connect Tasmania to Australia's national electricity grid. The proponent for this cable is National Grid International Limited (NGIL).

A Joint Advisory Panel (JAP) has been appointed by the Tasmanian, Victorian and Commonwealth governments to assess the "Integrated Impact Assessment Statement" required from NGIL in support of the Basslink proposal. In October 2000, the JAP issued the "Final Scope Guidelines for the Integrated Impact Assessment Statement (IIAS)". The IIAS is to be submitted to the JAP by NGIL and must address impacts of Basslink on a range of issues including visual amenity, flora and fauna, marine and coastal processes, cultural heritage, social and economic issues, public health and safety, greenhouse gas emissions, geology and hydrology.

The Final Scope Guidelines cover not only environmental, social and economic issues directly associated with construction and operation of the cable, but also issues associated with water management changes in Tasmania arising from operation of the Basslink cable. Specific sections of the IIAS guidelines require assessment of environmental, social and economic impacts related to changed water management practices in the Hydro Tasmania generating system, and these are highlighted in Section 1.2 of this report. The emphasis of the assessment is on the environmental effects of any changed hydro power generation regime adopted due to Basslink, as compared to the current condition.

NGIL is the company which will build, own and operate Basslink. NGIL is operating in Australia through its wholly owned subsidiary Basslink Pty. Ltd. (BPL). Changes to Tasmanian water management practices are a secondary impact of Basslink, the primary impact being construction and operation of the cable itself. Changes to power station operations and lake level management are the responsibility of Hydro Tasmania and not within the control of the NGIL. Hydro Tasmania water management responsibilities and programs, including the legislative and policy framework within which it operates, are identified in Section 1.3 of this report.

This document has been prepared by Hydro Tasmania, and summarises the results of its investigations into the impacts of changed water management practices in Tasmania due to Basslink. NGIL will incorporate the information summarised in this document into the Basslink IIAS, to ensure that the IIAS covers all the requirements of the JAP's Final Scope Guidelines.

1.2 IIAS Requirements for Assessment of Tasmanian Water Management

The Final Scope Guidelines for the Basslink IIAS were finalised and released in October 2000 by the Basslink Joint Advisory Panel.

The major headings required to be addressed by the IIAS, and the aspects of these requirements which are addressed in this report, are outlined below.

Chapter 1. *Introduction* - purpose of the report, project outline. Not addressed in this report, refers to the project as a whole.

Chapter 2. *Legislative Requirements* - all relevant Commonwealth, Tasmanian and Victorian legislative provisions affecting approval for the project. The Tasmanian legislative framework most directly affecting water management, the *Water Management Act* 1999, is described in Section 1.3 of this report.

Chapter 3. *Government Policy Context* - all relevant international, Commonwealth, State and Local Government policies and strategies with which the project should comply. The Tasmanian *State Policy on Water Quality Management* 1997 is described in Section 1.3 of this report.

Chapter 4. *Public Consultation*. General communication about the research and findings is addressed in Section 1.4. Assessments of public use issues for the identified Basslink-affected waterways are summarised in Sections 3.7, 4.7 and 5.7 of this report.

Chapter 5. *Need for the Proposal and Evaluation of Alternatives*. Relates to the overall Basslink project and not the Hydro Tasmania water management changes, so not addressed in this report.

Chapter 6. *Project Description*. IIAS Section 6.7, on the Relationship between Basslink and the Tasmanian Hydro-Electric Corporation's Operating System, is addressed in this report largely in Section 2, although Sections 3.2.1, 4.2.1, 5.2.1 and 6 are also relevant.

Chapter 7. *Description of Route Corridor and Sites*. Relates to the overall Basslink project and not the Hydro Tasmania water management changes, so not addressed in this report.

Chapter 8. *Potential Environmental Impacts and their Management.* IIAS Section 8.3 is very directly addressed by this report, most particularly the requirements to assess impacts of changed power generation on marine and coastal, land, surface water, groundwater and flora and fauna. Sections 3, 4 and 5 of this report are largely directed towards this requirement of the IIAS, and utilise the same headers as the IIAS for ease of incorporation.

Chapter 9. *Potential Social Impacts and their Management*. IIAS Sections 9.4.2 (public safety), 9.5.2 (visual impacts) and 9.6.2 (cultural heritage sites) are all focussed on impacts of changed hydro power generation on these issues. These are specifically addressed under the appropriate headers in Sections 3.7, 4.7 and 5.7 of this report.

Chapter 10. *Potential Economic Impacts and their Management.* IIAS Section 10.7.4 requires an assessment of industries affected by any changed hydro-power generation regime. This requirement is addressed by Sections 3.7.5, 4.7.5 and 5.7.5 of this report.

Chapter 11. *Impact on Tasmanian Wilderness World Heritage Area (TWWHA).* IIAS Section 11 has specific requirements which must be met by the Basslink IIAS on implications of the project for the TWWHA, and this information is met by this report. All of the Gordon River downstream of the Gordon Dam is within the TWWHA, and investigations of power station influence on the aquatic environment in this area is the focus of Section 3 of this report. Specific requirements of this section are:

- *Description of existing regulated condition.* Provided in Section 3.2.1 of this report.
- *Determination of WHA values potentially impacted.* Provided in Section 3.8 of this report.
- *Description of methods to assess impacts on WHA values.* Disseminated as appropriate throughout Sections 3.2 through 3.9.

- *Determination of sufficient baseline data.* Considered in Section 3.8.6 of this report.
- *Results of environmental studies and mitigation proposals to enhance protection of WHA values.* Disseminated as appropriate throughout Sections 3.2 through 3.9.
- *Proposed monitoring program.* Provided in Section 3.10 of this report.

Chapter 12. *Impact of Project Not Proceeding.* This requirement as it relates to hydro-power generation is met by the descriptions of existing conditions and trends in Sections 3, 4 and 5 of this report.

Chapter 13. *Environmental Management* **–** an outline of the comprehensive Environmental Management System which would be prepared for construction and operation of Basslink. This requirement relates to the overall Basslink project and not the Hydro Tasmania water management changes, so not addressed in this report.

Chapter 14. *Conclusion.* This IIAS section draws together the critical environmental, social and economic effects of the project, and draws conclusions on the ability of the project to further the objectives of sustainable development. This requirement as it relates to hydro-power generation is fully met by Section 7 of this report.

Chapter 15. *Commitments.* IIAS Section 15.2 requires a consolidated list of major commitments by the Tasmanian Hydro-Electric Corporation. This requirement is met by Section 7.4 of this report.

Chapter 16. *References.* Provided in Section 8 of this report.

1.3 Water Management Responsibilities of Hydro Tasmania

1.3.1 Legislative Framework

Hydro Tasmania manages a number of Tasmanian waterways for the purpose of electricity generation. Hydro Tasmania operations have a major influence on a large proportion of Tasmania’s waterways, and must comply with the existing water and environmental management framework in Tasmania which aims for sustainable management of these waterways. This legislative framework includes but is not limited to:

- The *Water Management Act* 1999;
- The *State Policy on Water Quality Management* 1997; and
- The *Environmental Management and Pollution Control Act* 1994.

The first two most directly relate to water management issues. Hydro Tasmania is a licence holder under the Tasmanian *Water Management Act* 1999, and as such must act in a manner consistent with the objectives of the Act, which are to:

- promote sustainable use and facilitate economic development of water resources;
- recognise and foster the significant social and economic benefits resulting from the sustainable use and development of water resources for the generation of hydro-electricity and for the supply of water for human consumption and commercial activities dependant on water;
- maintain ecological processes and genetic diversity for aquatic ecosystems;
- provide for the fair, orderly and efficient allocation of water resources to meet the communities needs;
- increase the communities understanding of aquatic ecosystems and the need to use and manage water in a sustainable and cost efficient manner; and
- encourage community involvement in water resource management.

The *Water Management Act* 1999 allows for the development of Water Management Plans, which give high priority to the needs of ecosystems and should include:

- an assessment of the quantity of water needed by the ecosystems that depend on a water resource and the times at which, or the periods during which, those ecosystems will need that water; and
- an assessment of likely detrimental effects, arising from the taking or use of water from the resource, on the quantity of water that is available to meet the needs of the ecosystems that depend on the resource; and
- an assessment of likely detrimental effects of the plan on the quality of the water.

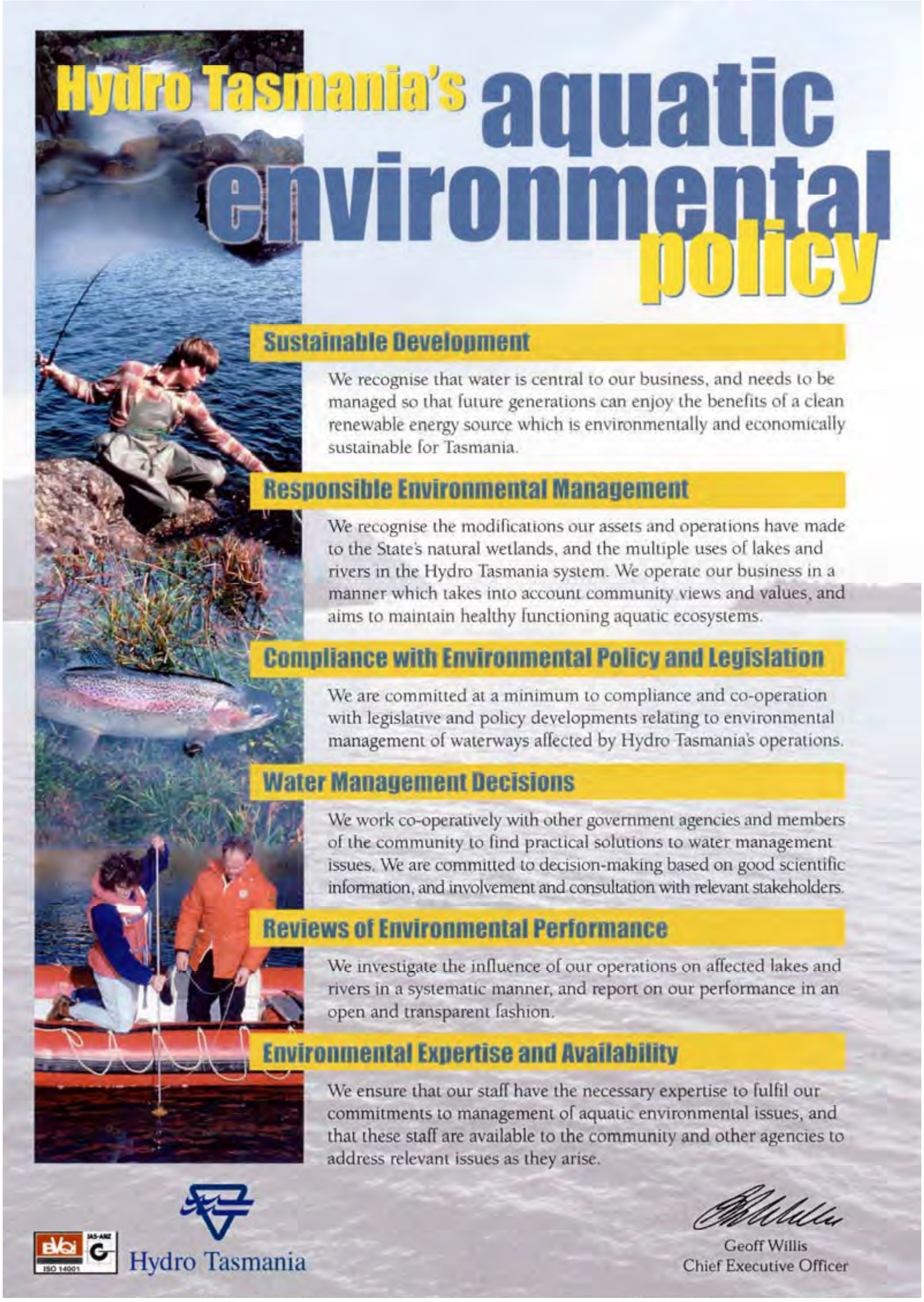
Hydro Tasmania is committed to working with the Department of Primary Industries, Water and Environment (DPIWE) in the development of Water Management Plans for the catchments in which it operates. This process is already underway in the Great Lake / South Esk Catchment (see Section 1.3.2).

The *State Policy on Water Quality Management* 1997 establishes a process for the setting of Protected Environmental Values (PEVs) for water quality. The PEVs will be used by DPIWE to set Water Quality Guidelines (WQGs) and Water Quality Objectives (WQOs). PEVs are values or uses of the environment for which it has been determined that a given waterway should be protected. WQGs are the indicator levels that need to be met in order to protect an environmental value. WQOs are the most stringent water quality guidelines for a specific body of water, and they are designed to ensure that the water quality of a nominated body of water is maintained at a level to achieve all of the PEVs developed for that body of water. WQOs are set by the Board of Environmental Management and Pollution Control, and will provide important targets in a range of planning documents, including catchment management plans.

1.3.2 Hydro Tasmania Aquatic Environmental Management Programs

Hydro Tasmania developed an **Aquatic Environmental Policy** in 1998 (see Figure 1.1). The Aquatic Environmental Policy describes Hydro Tasmania’s position regarding environmental management of its waterways in six key areas. These areas are: sustainable development, responsible environmental management, compliance with environmental policy and legislation, water management decisions, reviews of performance, and environmental expertise and availability.

To ensure implementation of its Aquatic Environmental Policy, Hydro Tasmania has put significant efforts into developing and implementing its **Aquatic Environment Program**. This program aims to manage its resources in an environmentally sustainable manner, be more aware of community views and values, and be more responsive to community concerns. Hydro Tasmania recognises that it is a major water manager in Tasmania as well as a generator of electricity, and needs to manage resources in an ecologically sound manner. This will ensure that present and future generations can enjoy the benefits of both a healthy environment and a clean, renewable source of energy.



Hydro Tasmania's aquatic environmental policy

Sustainable Development

We recognise that water is central to our business, and needs to be managed so that future generations can enjoy the benefits of a clean renewable energy source which is environmentally and economically sustainable for Tasmania.

Responsible Environmental Management

We recognise the modifications our assets and operations have made to the State's natural wetlands, and the multiple uses of lakes and rivers in the Hydro Tasmania system. We operate our business in a manner which takes into account community views and values, and aims to maintain healthy functioning aquatic ecosystems.

Compliance with Environmental Policy and Legislation

We are committed at a minimum to compliance and co-operation with legislative and policy developments relating to environmental management of waterways affected by Hydro Tasmania's operations.

Water Management Decisions

We work co-operatively with other government agencies and members of the community to find practical solutions to water management issues. We are committed to decision-making based on good scientific information, and involvement and consultation with relevant stakeholders.

Reviews of Environmental Performance

We investigate the influence of our operations on affected lakes and rivers in a systematic manner, and report on our performance in an open and transparent fashion.

Environmental Expertise and Availability

We ensure that our staff have the necessary expertise to fulfil our commitments to management of aquatic environmental issues, and that these staff are available to the community and other agencies to address relevant issues as they arise.

Hydro Tasmania

Geoff Willis
Chief Executive Officer

Figure 1.1 Hydro Tasmania's Aquatic Environmental Policy

As part of its Aquatic Environment Program, Hydro Tasmania is well-progressed in a program of review of its water management practices across the State, on a catchment-by-catchment basis, referred to as its **Water Management Review** (WMR) program. The aim of these reviews is to ensure that Hydro Tasmania is managing its water resources in an environmentally, socially and economically sustainable manner. The review process has been standardised for each of the 7 major catchment groupings being assessed, and includes the following stages:

Stage 1. **Background Information.** This stage involves collating information on Hydro Tasmania infrastructure and operating patterns within the catchment under consideration, and summarising any known information on environmental concerns relating to Hydro Tasmania operations in the catchment. The outcome of this stage is an "Environmental Review" document for the catchment area. The Hydro Tasmania Environmental Review document for the Great Lake – South Esk catchment area can be viewed on the Hydro Tasmania web site, at *http://www.hydro.com.au*

Stage 2. **Community Consultation**. This stage involves constructing a very comprehensive stakeholder database including directly affected landowners, interest groups utilising Hydro Tasmania affected wateways, and government bodies, and directly contacting each of these stakeholders. Advertisements and radio interviews are also conducted to make any other interested stakeholders aware that they can be included on the WMR stakeholder database. All stakeholders are offered a free copy of the Environmental Review document for the catchment under consideration, followed by a detailed survey questionnaire asking for information on any areas of concern related to existing Hydro Tasmania operations in the catchment. Follow-up telephone calls and personal visits are offered to all stakeholders. Results of the consultation are summarised in a Community Consultation document, which is made freely available to all on the stakeholder database for the catchment under consideration. Results of the consultation, and plans for the next stages of the WMR, are also presented at a series of public meetings which are advertised, and individual invitations sent to all on the stakeholder database. The Community Consultation report for the Hydro Tasmania Great Lake – South Esk WMR can be viewed on the Hydro Tasmania web site, at *http://www.hydro.com.au*

Stage 3. **Technical Studies**. This stage involves a series of technical studies which investigate the issues of concern raised in the community consultation stage. Studies are very focussed on what actions can be put into place to address these issues of concern, and may take up to two years. The outcome of this stage is a series of technical reports accompanying a summary report, and again a series of advertised public meetings.

Stage 4. **Program Development**. This stage involves design of a program of action for the Hydro Tasmania business to address the issues investigated.

Hydro Tasmania's water management reviews are being conducted alongside and with the full endorsement of DPIWE. It is anticipated that DPIWE will take the outcomes of Hydro Tasmania's water management reviews one step further, and develop Water Management Plans for these catchments under the *Water Management Act* 1999. The first of the Hydro Tasmania water management reviews is presently well advanced in the Great Lake-South Esk catchment, and the Derwent-Nive catchment WMR is also underway.

In addition to the Water Management Reviews, the Aquatic Environment Program also encompasses:

- A **Waterway Health Monitoring Program**, which routinely assesses the health of lakes and rivers influenced by Hydro Tasmania activities. Hydro Tasmania, in conjunction with the Inland Fisheries Service, conducts regular monitoring of water quality, biological and physical condition assessments in its lakes and rivers, along with more detailed monitoring where warranted (e.g. Lagoon of Islands). This program will be supplemented by a Basslink Monitoring Program (see sections 3.10, 4.9 and 5.9 of this report) if the Basslink project proceeds.
- A fish migration project which involves an in-depth analysis of existing Hydro structures and natural barriers to fish migration, as well as the biology and ecology of Tasmania's native fish fauna.
- Threatened species assessments, which involve analysis of distributions of these species in conjunction with risk analyses and evaluation of threat sources using GIS software. Hydro Tasmania has been a major contributor to a recovery plan for several Tasmanian native fish species: the Pedder galaxias, swamp galaxias and saddled galaxias. Measures have been put in

place in several key waterways to control movement of exotic fish, as they can be a major threat to Tasmania's native fish species.

Managing water for environmental objectives has been clearly demonstrated as an important priority for Hydro Tasmania through many commitments, including (but not limited to) minimum environmental flow releases, constraints on management of water levels in numerous lakes, construction of barriers to exotic fish migration and ladders for native fish passage, modifications to water transfer infrastucture to improve water quality and consequently threatened species habitat in a number of waterways, and substantial commitments to ongoing environmental investigations and monitoring.

In summary, there is a well-developed and comprehensive water management framework in Tasmania to ensure sustainable environmental management of its water resources, and Hydro Tasmania has an advanced policy, program and record of achievement to demonstrate its commitment to this objective.

1.4 Approach to Hydro Tasmania Investigations

The approach to the Hydro Tasmania investigations has involved the following steps:

1. Preliminary modelling of the Hydro Tasmania system incorporating a Basslink cable;
2. Identification of areas of changed water management due to Basslink operation of the Hydro Tasmania generating system;
3. Identification of potential environmental issues in the identified waterways;
4. Detailed hydrological analyses of the changes in water management;
5. Environmental study design to investigate identified issues;
6. Environmental investigations including field assessments and assessments of public use issues (October 1999 – January 2001);
7. Identification of environmental management issues and mitigation options;
8. Investigation of mitigation options;
9. Development of a monitoring program;
10. Sensitivity analyses on model predictions to assess robustness of conclusions of these investigations; and
11. Reporting.

Hydro Tasmania has undertaken its investigations of the environmental implications of Basslink changes to its present operating practices in a manner consistent with its commitments in the Aquatic Environmental Policy. The approach has shown a commitment to decision-making based on good scientific information, the involvement of and consultation with relevant stakeholders, and working in a co-operative and responsible manner to find practical solutions to water management decisions. Importantly, the investigations and assessments of mitigation options have been within the context of Hydro Tasmania's commitment to sustainable development.

The focus of the investigations has been on the environmental implications of changes from the existing flow regime to a Basslink flow regime. The three river systems under consideration are all substantially modified by flow regulation, and also, in the case of downstream Poatina and John Butters power stations, by surrounding land use practices. Basslink causes further adjustments to river systems that have already experienced and are still experiencing adjustments to flow regulation. Investigations have required an understanding of the ecological processes and trends presently affecting the river ecosystems, as a baseline against which to identify and assess the dominant Basslink processes and trends. An important requirement is to understand the existing degree of variability in power station discharge regimes, as a context for the Basslink changes.

The assessment of Basslink changes to the Hydro Tasmania generating system requires comparison of existing operating patterns with output from a simulation model of Basslink operating patterns. Any modelling approach requires a number of assumptions to be made, and the set-up of a model can introduce biasses to the model output. In recognition of these factors, the approach used for this present analysis has been highly conservative. The characteristics of the TEMSIM model used for this study (see Section 2.3) undoubtedly lead to an over-estimation of the Basslink impacts to Hydro Tasmania operating patterns. To be conservative, researchers undertaking the environmental investigations summarised in this report were asked to assess the environmental implications of Basslink with the given model predictions. As a consequence, environmental impacts identified for Basslink are likely to be over-estimated. This is discussed where appropriate in this report.

The approach has been highly consultative throughout the investigations, including the following activities:

- In February 2000 the Scoping Report (Appendix 1) was completed. It details changes to the non-marine aquatic environment after the installation of Basslink, and outlines the program of further studies to be undertaken for these investigations. It was distributed to a range of stakeholders for information and feedback, and posted on Hydro Tasmania's web-site.
- Hydro Tasmania has consulted with stakeholders prior to and subsequent to the release of the Scoping Report. This has involved presentations to the World Heritage Area Consultative Committee (twice), a workshop and field visit involving Tasmanian regulators (Department of Primary Industries, Water and Environment and Inland Fisheries Service), a presentation and field visit for members of the Joint Advisory Panel, and close consultation with individual landowners downstream of Poatina Power Station.
- Consultation with stakeholders in the South Esk, Gordon and King River catchments specifically for the Basslink investigations was undertaken, and resulted in three separate consultation reports included as part of the Hydro Tasmania Basslink environmental report series (Appendices 13, 21 and 28).
- Members of the Tasmanian Department of Primary Industries, Water and Environment (DPIWE) reviewed 28 of the reports in the Hydro Tasmania Basslink environmental report series, and provided comment and feedback which received more one-on-one or small group discussion where warranted.
- Two full-day workshops with key Basslink environmental researchers and DPIWE, the Inland Fisheries Service and Environment Australia staff were conducted in February and March 2001.
- Hydro Tasmania has also conducted briefings for the Tasmanian aquaculture industry, the business community, a number of politicians and media representatives.
- Running alongside the Hydro Tasmania investigations and as part of Hydro Tasmania's aquatic environmental program, highly consultative Water Management Reviews are underway or planned for each of its catchments (as described in Section 1.3.2). The most advanced of these is the Water Management Review for the South Esk – Great Lake catchment. During 2000, consultation was undertaken with over 200 stakeholders and interest groups. This involved mailed surveys, direct communication with stakeholders through phone calls and personal visits, and public meetings. Two publications associated with this program – *Environmental Review* and *Community Consultation Report* – are posted on Hydro Tasmania's web-site.

1.5 Outline of this Summary Report

Section 2 provides a summary of predicted changes to Hydro Tasmania water management with a Basslink cable in operation. Sub-sections describe the existing generating system, existing variability and trends, the National Electricity Market, the modelling utilised to assess Hydro Tasmania water management changes arising from Basslink, model outcomes, and the environmental investigation program for Hydro Tasmania water management changes due to Basslink.

Based on the modelling assessments described in Section 2, three power stations were identified as requiring assessment of environmental issues related to identified water management changes due to Basslink. These are the Gordon, Poatina and John Butters power stations, shown on Map 2.2 in the following section. Sections 3, 4 and 5 of this report respectively address these power stations. Each of these sections provides background information on the catchment and power station operation, describes the predicted Basslink changes, and summarises the results of environmental investigations into a range of identified environmental issues. Environmental investigations are grouped under the major headers of Surface Water, Land, Flora and Fauna, Groundwater, Marine, and Socio-Economic for each river system under consideration, to reflect the requirements of the IIAS Guidelines. Each section provides a summary of environmental management issues and mitigation options, as well as the proposed Basslink Monitoring Program for that river system.

Consideration of Basslink monitoring is covered in a number of sections in this report. Each researcher was asked to present monitoring considerations on the discipline under assessment in the individual reports (the appendices to this report). All of the researchers' monitoring considerations, regardless of whether they are directed at Basslink monitoring or broader suggestions, are summarised at the end of each appropriate sub-section summarising the work of that researcher (e.g. at the end of Sections 3.3, 3.4, etc.) in Sections 3, 4 and 5. This is followed by identification of the monitoring components that Hydro Tasmania proposes to incorporate into its Basslink monitoring program. Other researcher suggestions are also listed, for consideration in any further studies. The proposed Basslink monitoring for each main river system are pulled together in Sections 3.10, 4.9 and 5.9. These sections propose the detailed monitoring programs to which Hydro Tasmania will commit to accompany the Basslink development. Where reference is made to a Basslink monitoring program involving three years pre-Basslink and three years post-Basslink, it is assumed that the investigations undertaken during 2000 constitute the first year of the pre-Basslink monitoring program.

Section 6 presents a review of the initial modelling results (which were presented in the Scoping Report, Appendix 1) using the final cable specifications and the most up-to-date modelling assumptions. It also presents sensitivity analyses undertaken on the key model input parameters of system load and power price. The implications of the model output for the conclusions on environmental impacts from Sections 3, 4 and 5, given the updated assumptions and variations in the key input parameters, are assessed.

Section 7 of this report provides a summary of environmental impacts of Hydro Tasmania water management changes arising from Basslink. In this section, Hydro Tasmania business commitments to mitigate Basslink environmental issues of concern are clearly outlined.

Section 8 provides a list of references.

29 separate appendices accompany this summary report, and can be viewed on the Hydro Tasmania web site, at http://www.hydro.com.au. These reports are:

Appendix 1	Scoping Report: Basslink Aquatic Environmental Project
Appendix 2	Gordon River Hydrology Assessment
Appendix 3	Gordon River Water Quality Assessment
Appendix 4	Gordon River Fluvial Geomorphology Assessment
Appendix 5	Gordon River Karst Assessment
Appendix 6	Gordon River Riparian Vegetation Assessment
Appendix 7	Gordon River Macroinvertebrate and Aquatic Mammal Assessment
Appendix 8	Gordon River Fish Assessment
Appendix 9	Gordon River Terrestrial Fauna Assessment
Appendix 10	Gordon River Cave Flora and Fauna Assessment
Appendix 11	Gordon River Meromictic Lakes Assessment
Appendix 12	Gordon River Cultural Heritage Assessment
Appendix 13	Gordon River Public Use Assessment

Appendix 14	Gordon River World Heritage Area Values Assessment
Appendix 15	Downstream Poatina Hydrology Assessment
Appendix 16	Downstream Poatina Water Quality Assessment
Appendix 17	Downstream Poatina Geomorphology Assessment
Appendix 18	Downstream Poatina Instream Biota Assessment
Appendix 19	Downstream Poatina Terrestrial Biota Assessment
Appendix 20	Downstream Poatina Cultural Heritage Assessment
Appendix 21	Downstream Poatina Landowner Issues Assessment
Appendix 22	King River Hydrology Assessment
Appendix 23	King River Water Quality Assessment
Appendix 24	King River Geomorphology Assessment
Appendix 25	King River Instream Biota Assessment
Appendix 26	Macquarie Harbour Water Quality Assessment
Appendix 27	King River Cultural Heritage Assessment
Appendix 28	Downstream John Butters Public Use Assessment
Appendix 29	TEMSIM Sensitivity Study on Implications of Basslink

2 PREDICTED HYDRO TASMANIA WATER MANAGEMENT CHANGES DUE TO BASSLINK

Section 2 begins with a description of the existing Hydro Tasmania generating system (Section 2.1). The Basslink development in the context of the National Electricity Market is then described (Section 2.2), followed by a description of the modelling used for this study to predict changes to the Hydro Tasmania generating system due to Basslink (Section 2.3). In Section 2.4 model outputs are presented, and investigations of riverine issues arising from Basslink changes are outlined in Section 2.5.

2.1 Hydro Tasmania's Generating System

2.1.1 Overview

Hydro Tasmania's generating system consists of a network of 51 dams and 27 hydro-electric power stations. In addition, a thermal power station is located at Bell Bay and can be utilised to supplement generation if there is a projected short-fall in system ability to meet demand. Hydro Tasmania has an installed capacity of 2,509 MW (hydro-electric power stations only), and currently generates an average of 1,141 MW, with a system peak generation of around 1,596 MW. An overview of Hydro Tasmania's storages and infrastructure is shown on Map 2.1.

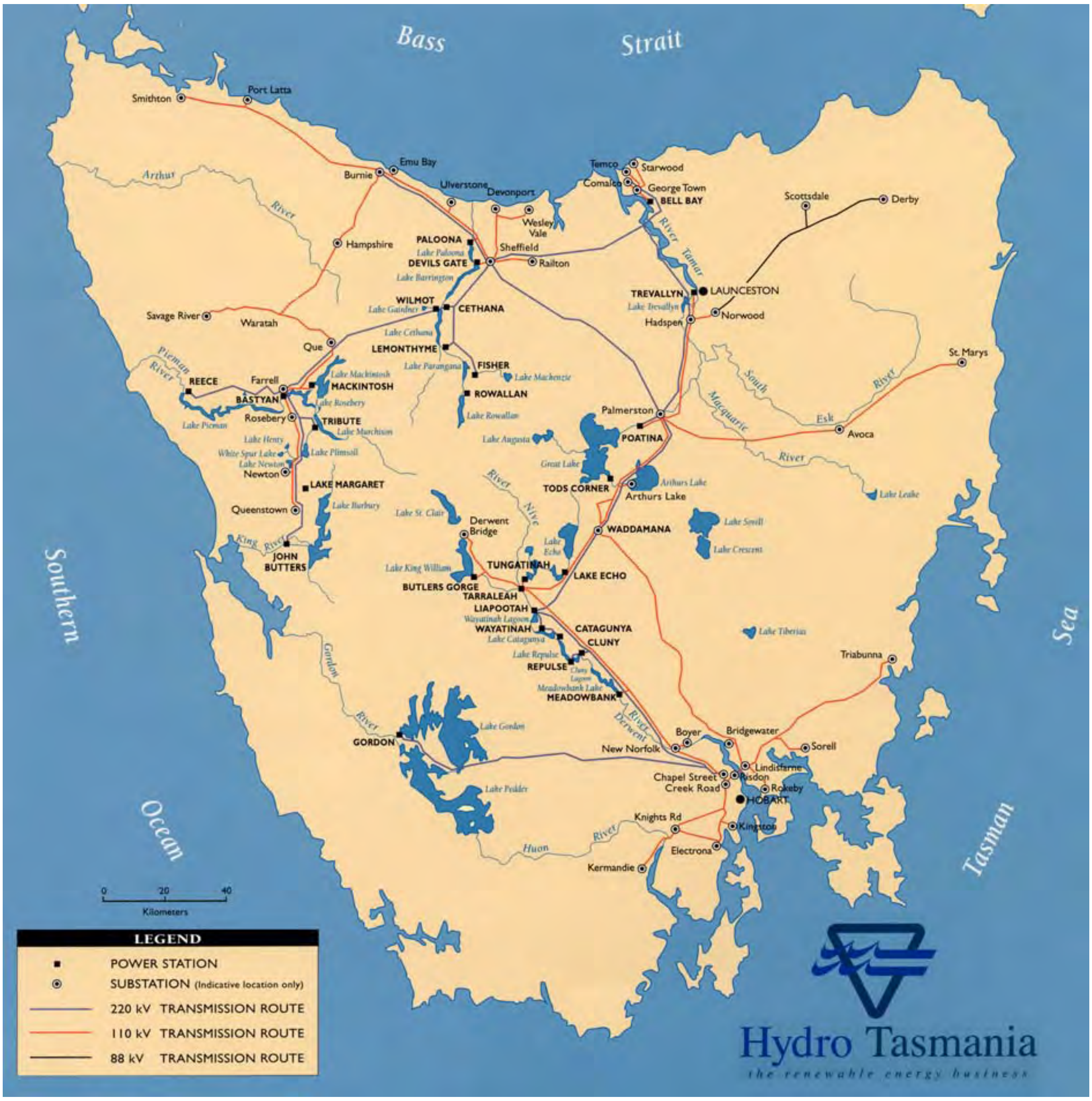
A description of how the system storages and power stations are currently operated is provided in detail in Appendix 1 of this report series, the "Scoping Report". Information from this Appendix is summarised in this section.

The objectives of the present Hydro Tasmania operating system are two-fold:

1. to operate a secure power system in order to meet customer requirements in terms of energy, capacity and quality of supply; and
2. to operate the integrated hydro power system efficiently while satisfying hydrological, electrical, legislative, social and environmental constraints.

To meet these objectives, Hydro Tasmania has developed and uses a system planning regime. The operating system is planned for the long term (10 years), the medium term (2 years), the short term (3 months). Half hourly generation scheduling and real–time operation extends from the immediate to one week ahead. In planning the operation of the system, various constraints apply, including safety, electrical, hydraulic, maintenance, irrigation, environmental, hydrological, commercial and recreational considerations.

Storages in the Hydro Tasmania system can be categorised into three types; minor, medium and major. These categories are based on the typical time it takes to fill or empty the storage under normal inflow conditions. Although storage size is generally the major category determinant, catchment area and associated power station size are also relevant. Minor storages are limited in storage volume capacity and have an inflow regime and discharge capacity that makes it possible to fill or empty them over a period of hours to days. Medium storages, usually the top storage of a cascade of minor storages (eg Lake King William, Lake Rowallan), cycle over a period of months or a season or two. There are two major storages, Lake Gordon and Great Lake, which have a life cycle of decades. This long length of time to fill or empty these two storages makes them a safe repository of excess energy in times of plenty, and a source of reserve energy in times of drought (see Map 2.1).



Map 2.1 Tasmania's Electricity System 2001.

The Hydro Tasmania generation system is managed to maximise operational efficiency. A major part of this is to minimise losses due to spilling water out of the storages, past the generators. Operating policy and daily power station generation scheduling is largely determined by proximity of storages to spill; the priority order of storage use and the energy value to be achieved by water release are both directly determined by storage probability of spill. This objective results in the following general storage use priorities for planning a generation schedule:

1. Use any storage spill. This is water that would otherwise spill and therefore bypass the generators.
2. Use pickup into minor storages. These storages have limited capacity and are therefore likely to spill if inflow is not utilised;
3. Use water out of the medium storages; and
4. Use water out of the major storages.

There are a number of level controls used with individual storages that limit their water release, effectively stepping to the next storage in priority order and thereby ensuring a balanced use of water from all storages.

A second part of maximizing operational efficiency is to operate the generators themselves as efficiently as possible. A generator is capable of a range of outputs with its most efficient point, measured as maximum power for water used, at about 85% of maximum capacity. To meet the power demand at any point of time, the output from a number of generators is required. The aim is to have as many of these generators as possible on their maximum efficient generation point. This is not always possible. There are three major circumstances that mitigate against this aim:

1. When water is scarce, generation from medium and major storages releases may have to be at maximum capacity to meet demand;
2. When water is abundant, maximum capacity operation is required to avoid spill; and
3. Plant is often operated at low output to provide reserve generation capacity to protect the system in case of an unforeseen event.

Bell Bay is Hydro Tasmania’s only thermal generator in mainland Tasmania and is used for long and short term drought support. Bell Bay is used as the lowest priority generator on the system because of its high cost of operation. Fuel oil is expensive and the plant itself has high operational costs, both in terms of staff and plant maintenance. Bell Bay is brought into operation when the total system energy in storage falls below the ‘thermal control' level or the medium storages fall to a critically low level.

The Thermal Control is derived to ensure a desired system security with minimum expenditure on thermal generation. The thermal control rule describes a dynamic control level, the threshold changing in response to forecast load and system yield. Medium storages can be drawn to low levels in critically dry years; when this occurs Bell Bay is operated to support these storages.

2.1.2 Trends and Variability in Hydro Tasmania System Operations

It is important to understand the dynamic framework against which the Basslink changes must be compared. The Basslink development is one of a series of changes which has affected the operations of the Hydro Tasmania generating system over time. The Tasmanian electricity generating system has grown over time as new power schemes were built, thereby increasing the system capability to meet the accompanied growth in load (electricity demand) over time. The transmission system in Tasmania has also grown over time to accommodate the changes in generation infrastructure, and this system is the focus of continual upgrades and refinements.

The long-term trends in growth of Tasmania’s total generating system capacity and average annual load are clearly illustrated in Figure 2.1. Notable from this figure is that the load in the year 2000 is at the top end of range of existing system capability. There is a clear need for new generation capacity in Tasmania to meet load growth, hence the pursuit of major energy projects for the State (Basslink, wind, gas).

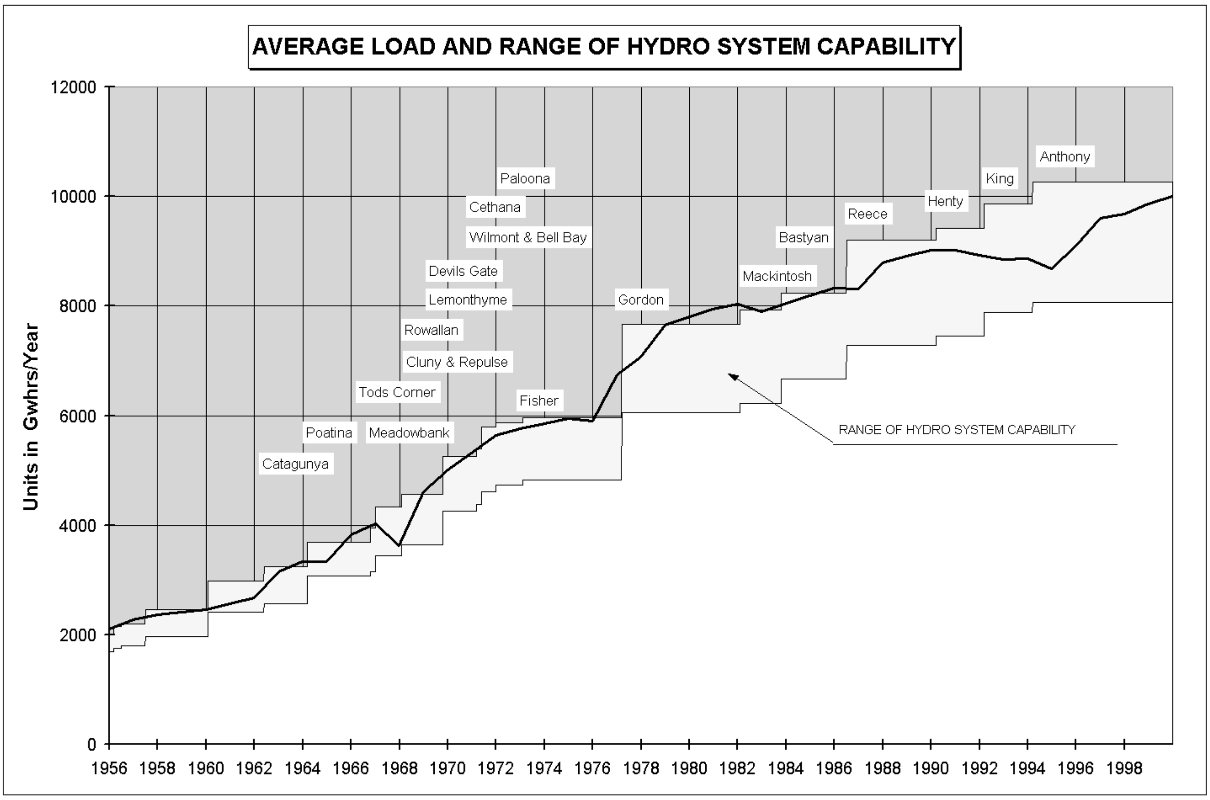


Figure 2.1 Average Load and Range of Hydro System Capability from 1956 to 2000

There is considerable inter-annual variability in the total inflows to the generating system over time, as is shown in Figure 2.2. This figure shows the total system yield (inflows to all of the storage lakes) between 1924 and 1998, with a recent 'wet' year (1996) and 'dry' year (1989) for the system as a whole indicated. Lake level fluctuations and discharge patterns for the power stations which draw water from the smaller lakes are most influenced by local rainfall into the storages – when the water is there, the power stations are run. However, for the power stations which draw water off of the large storages, their operational patterns reflect the amount of total inflows to the generating system. Data are presented in more detail in this report (Sections 3.2.1, 4.2.1 and 5.2.1) to show the variability in power station operations for Gordon, Poatina and John Butters between a wet year and a dry year for the system as a whole.

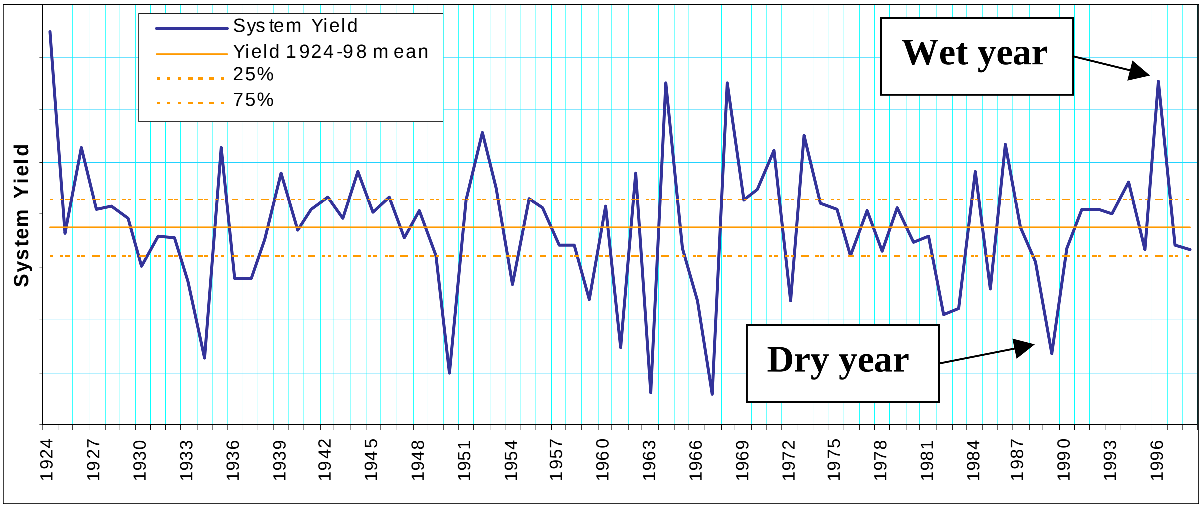


Figure 2.2 Hydro Tasmania System Yield 1924-1998

Tasmania’s hydro-electric power stations also exhibit seasonal, daily and hourly trends in operation, and these trends will vary amongst power stations depending on factors additional to rainfall patterns, including the size of their storage, the capacity and peculiarities of the generating infrastructure, and their location in the State in relation to transmission pathways and centres of demand.

Potential Basslink changes to the present hydro-power generation patterns in Tasmania must be viewed within the context of an already highly variable system. As will be seen, Basslink is likely to reduce variability on some time scales (e.g. inter-annual, seasonal, daily) but increase it on other timescales (e.g. hourly). The details of these changes and their environmental implications are the subject of the remainder of this report.

2.2 Basslink and the National Electricity Market

Basslink is a development which would enable Tasmania to become a participant in the National Electricity Market (NEM). Basslink will not be owned, controlled or operated in any way by Hydro Tasmania. Basslink will be owned by Basslink Pty. Ltd., which is a wholly-owned subsidiary of National Grid International Ltd.

With the Basslink development, Tasmania would be joining South Australia, Victoria, New South Wales and Queensland in the National Electricity Market. A detailed overview of the operations of the NEM is beyond the scope of this present report, but can be found at www.nemmco.com.au. In the context of the NEM, the Basslink cable is a ‘Market Network Service Provider’. Dispatch of electricity in the NEM is managed by the National Electricity Market Management Company Ltd. (NEMMCO). NEMMCO will ensure that the dispatch of electricity across Basslink is in keeping with the requirements of the National Electricity Code.

Basslink is being designed to allow NEMMCO to dispatch exports from Tasmania of up to 600 MW of electricity per half hour for a maximum of ten hours, and to import into Tasmania up to 300 MW of electricity per half hour. The average rated capacity of the link is 480 MW, and where 480 MW is used throughout this report it refers to this capacity for 600 MW export and 300 MW import.

There are twenty-four “generators” (producers and sellers as defined by NEMMCO) operating in the NEM. Price bids are submitted to NEMMCO by generators on a half-hourly basis. In the context of the Basslink development, NEMMCO will determine which generators in Tasmania and Victoria are scheduled on in response to the prevailing demand and the submitted price bids. NEMMCO will further determine the direction of flow of electricity across Basslink, and the volume of electricity that is transmitted across the link in any half-hour period. Note that Hydro Tasmania’s role is not to determine either the direction or the quantity of electricity transmitted across the link, but rather to place bids for provision of capacity (MW of available power) during specified time periods, and provide the energy for those bids which are accepted.

For the purposes of this present environmental analysis of the Basslink development, it is assumed that Hydro Tasmania is the sole Tasmanian generator. In the future, in any half-hourly dispatch by NEMMCO, the electrons transmitted across Basslink could be sourced from any Tasmanian generators including the Bell Bay gas-fired power station, wind generators, gas-fired co-generation plants and biomass plants. The sensitivity of model predictions used for this analysis to changes in the net load on the hydro system, as a consequence of changes to the market or to changes in the Tasmanian generating system, are summarised in Section 6 and Appendix 29.

2.3 Modelling Basslink Changes to Tasmanian Water Management

2.3.1 Model Development and Function

Modelling of the Hydro Tasmania generating system incorporating a Basslink cable was an essential requirement for assessing Hydro Tasmania water management changes due to Basslink.

For more than twenty years, Hydro Tasmania has utilised a simulation program of its electricity generation system to predict and run the system, known as SYSOP. SYSOP simulates the operation of the generating system to meet an assumed load. Each generator (60 in all) at all 28 power stations (including Bell Bay) is modelled, together with 40 significant water storages, pumps, conduits and siphons. All existing environmental constraints on Hydro Tasmania system operations, in the form of discharge requirements and lake level agreements, are included in the model. The model operates on an hourly time-step, and utilises 75 years of historical flow records as the inflow sequence. The performance of the SYSOP model received a favourable assessment in 1996 for its role in rating the system, by an independent audit team from BC Hydro, Canada. The auditors commented that SYSOP simulates the hydro system in much greater detail than other long-term models of predominantly hydro-electric systems.

To assess the proposed Basslink development, a variation on the SYSOP model known as TEMSIM (Tasmanian Electricity Market Simulation Model) was developed by Hydro Tasmania. TEMSIM models the Tasmania generating system according to market rules of the NEM, as explained in Section 2.2. The model sets up a generating schedule based on an NEM-type dispatch process. This process is founded on generation offers from participating generators in Tasmania, assessed against projected Victorian spot prices to determine electricity flows across Basslink. The model is complex and requires hour-by-hour consideration of:

- Inflows to and outflows from Hydro Tasmania storages;
- Hydro Tasmania system power demand;
- The value of the Tasmanian water in storage (based on a long-term marginal cost function for Great Lake and Lake Gordon related to the total energy in storage); and
- Forecasts of the Victorian system marginal price (these have been derived for Hydro Tasmania by Intelligent Energy Systems Pty. Ltd. using the PROPHET model, which replicates the principal elements of the NEMMCO scheduling, pricing and dispatch model, and is widely used by participants in all NEM regions).

These components are described in detail in Appendix 1 of this report series.

The NEMMCO dispatch process modelled in TEMSIM involves 'taking' generation from a prioritised list of offers (lowest price offered first) to meet demand in the two regions (Tasmania and Victoria). Initially, offers from generators are placed against demand in the region that the generator is located in. If demand has been met in that region, offers may then be placed against demand in the other region by means of a transfer across Basslink. In determining transfers of electricity across Basslink, an assumed loss of energy across the link is incorporated into the model. The list of offers is ultimately transformed into a generation dispatch schedule for the two regions.

Generally, electricity transfer from Victoria to Tasmania (imports from a Tasmanian perspective) will occur when the Tasmanian price is higher than the Victorian spot price. Conversely, exports from Tasmania will occur when the Victorian price is higher.

The Tasmanian spot price (which affects the generation dispatched) is affected by the market demand, the value of water in storage (i.e. its scarcity/abundance) which has a marked seasonal pattern, and competitor behaviour in the Tasmanian market. When lake levels in Tasmania are high, Hydro Tasmanian bids are likely to be accepted by NEMMCO and result in power station discharges and electricity dispatch across Basslink. The Victorian spot price is affected similarly by patterns of Victorian electricity demand and supply.

Tasmanian import and export of electricity across Basslink are anticipated to have strong daily and seasonal patterns:

- In general, a pattern of diurnal import and export flows is anticipated, with exports from Tasmania occurring during working weekdays of peak Victorian demand, and imports to Tasmania occurring overnight and on weekends which are off-peak periods for Victorian demand.
- Strong seasonal link flows are expected to overlay the diurnal pattern. Net exports are likely to occur during the wet winter-spring months when Tasmanian storages are high and prices are low, and net imports through the drier summer-autumn months. The latter net import flows include Tasmanian exports to the high-priced peak demand levels in Victoria during hot summer days when air conditioning is required. The strong daily double-peak pattern to winter demand associated with household consumption will also be a prime time for Tasmanian export flows.

Under extreme conditions, it is possible for import or export flows to be continuous for extended periods. This could occur, for example, in extended drought which may require Tasmanian supply to be supplemented by import flows. Conversely, extended export flows could occur in the event that the arrival in Tasmania of major new gas-fired or wind generation capacity creates a short-medium term surplus of energy in Tasmania.

TEMSIM models the patterns of import and export of electricity through Basslink using NEM spot price differentials in Victoria and Tasmania. These are based on the Victorian spot price projections derived from the PROPHET model, and Tasmanian storage inflows and levels which simulate ‘water value’ prices in Tasmania. However, with Basslink, Tasmania will be entering a market environment in which strategies will be employed to maximise energy trading values, and patterns of bidding will also reflect these broader financial objectives.

2.3.2 Characteristics of the TEMSIM Model

It is important to understand what is, and is not, incorporated into the TEMSIM model, and characteristics of the model set-up which have an influence on the model output.

The way the storages are “bid in” to the National Electricity Market reflects best available future predictions, but this may change or be refined in the future. The sensitivity studies undertaken in Appendix 29 show how variations in price may affect operation of the Hydro Tasmania generating system, and these are summarised in Section 6 of this report.

Maintenance can involve some periods of power station shutdown. Maintenance shutdown scheduling is not currently present in TEMSIM. Hydro Tasmania has been working for some time to shorten periods of power station shutdown for maintenance purposes, so by the time Basslink would be operational it is likely that maintenance programs will involve as few long power station shutdowns as possible. Major maintenance programs will still be required, with or without Basslink, for example on the Gordon intake gates (see Section 3.9.5.4).

TEMSIM does not simulate any transmission constraints to the transfer of power. Constraints in the transmission system do exist, and can result in restrictions in individual power station output. It is necessary to be aware of these constraints when comparing predicted Basslink trends (which don’t show the constraints) with historical operating patterns (which were influenced by the constraints).

Where these occur, they are pointed out in this report. Transend have an ongoing program to address areas of constraint in the transmission system for the State, and this program would be implemented regardless of the Basslink development.

TEMSIM does not take into account future cloud seeding activities. The historical inflow database includes the influence of past cloud seeding activities on the catchments, however future projections do not.

The TEMSIM model in its present configuration makes offers on a power station-by-power station basis without consideration for use of individual generators in the multiple generator power stations. TEMSIM offers an entire power station into the market at one price, rather than considering efficiency losses of generators and thus a range of different offers for one power station. In practice, it is more likely that power stations with more than one generator will operate over the range of available generators (one, two or three etc. generators operating at any one time), rather than always the whole power station. Output from the TEMSIM model for multi-generator power stations is therefore biassed towards efficient load or full gate discharge for all generators at that power station, rather than showing the more likely scenario in which power stations experience fluctuations between numbers of generators in operation. This bias makes predicted patterns of water discharge under a Basslink operating regime appear very “blocky” and extreme in range, going from zero discharge (power station shutdown) to full capacity discharge to zero discharge without utilising intermediate discharge levels. To be conservative as was discussed in Section 1.4, researchers for these investigations were asked to assess the environmental implications of Basslink with the given TEMSIM predictions, and so environmental impacts are likely to be over-estimated. This is discussed where appropriate in this report.

The TEMSIM model has some inadequacies in the scheduling of small to medium-sized storages in the lower parts of cascade systems (i.e. Derwent and Mersey Forth). Balancing of multiple head storage operation (Derwent and Mersey Forth) is also not fully optimised in the TEMSIM model. Because the TEMSIM modelling for these storages is relatively coarse, this contributes to the less efficient operation of the Hydro Tasmania system as a whole predicted by TEMSIM. In practice, implications of these modelling inadequacies is considered to be minimal. The small storages, which operate on a ‘run-of-river’ basis discharging whenever there are inflows, will not change due to Basslink. The medium-sized ‘head’ storages at the top of the cascades are also unlikely to change significantly under Basslink, as they must cycle annually to feed the downstream run-of-river storages, and Basslink will not change this requirement. In summary, trends in water levels in the small to medium sized storages are most strongly influenced by inflow patterns. Therefore the TEMSIM inadequacies in modelling of the small to medium-sized storages do not affect the scope or outcomes of the investigations presented in this report.

2.3.3 Utilisation of the TEMSIM Model

For the purposes of these analyses, TEMSIM model output is compared with historical data. The rationale for this comparative approach is that it:

- is consistent with the IIAS Guidelines which require assessment of changed hydro-power generation under Basslink, and description of the existing condition;
- provides a picture of how the system has been operating within the recent memory of stakeholders;
- allows analysis of the existing environmental condition by highlighting the influences and trends on that condition; and
- provides the most realistic baseline against which model predictions can be compared, rather than comparing TEMSIM outputs with outputs from another model of present system operations.

Limitations of this approach include:

- load and system infrastructure have changed historically, thus influencing the historical data;
- historical data limitations (especially with lack of hourly data) prevent extensive statistical analyses;
- limited historical data sets may not be representative of longer time periods; and
- historical data sets may not cover the same time period for different waterways.

As stated in Section 1.4, the approach taken for these investigations is considered to be highly conservative, in that Basslink impacts are likely to be over-estimated based on characteristics of the TEMSIM model and comparisons with historical data sets. The implications of the limitations of the TEMSIM model and/or historical data for the outcomes of these investigations are drawn out in this report where appropriate.

2.4 Outcomes of Preliminary Modelling

The initial assessment of potential environmental issues associated with changes to Hydro Tasmania operations due to a Basslink cable was undertaken through much of 1999. The results of this assessment were released in February 2000, and are presented in full in Appendix 1, the Scoping Report.

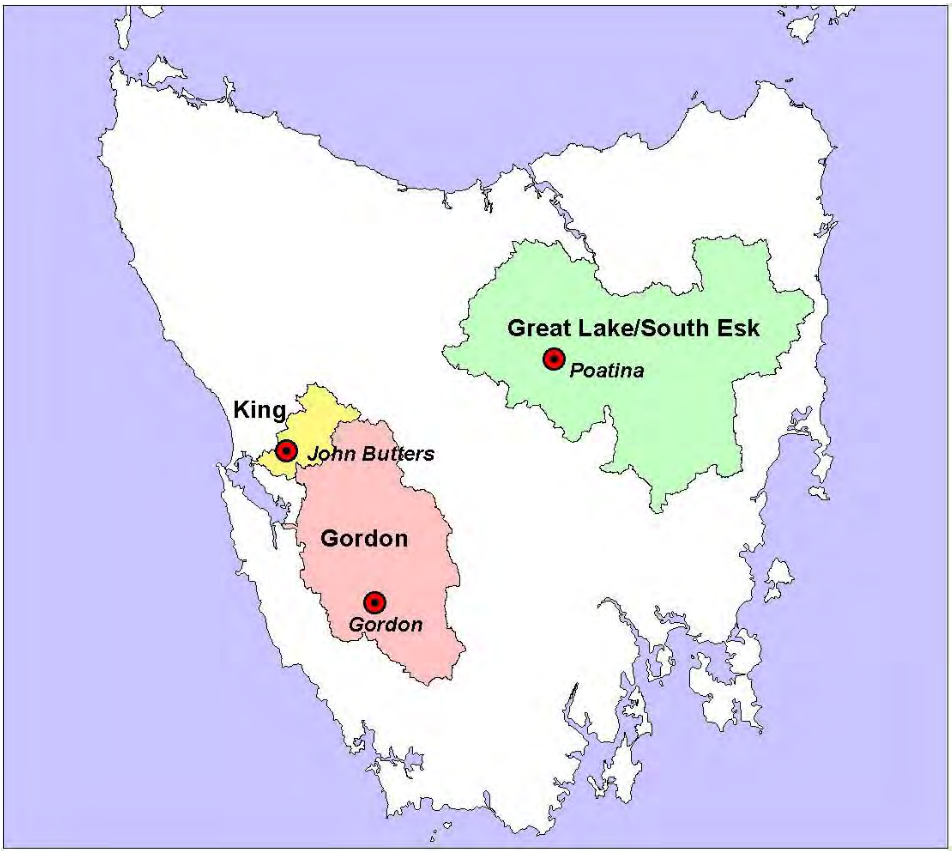
The approach pursued for this scoping exercise involved the following five stages:

1. Review of TEMSIM to assess the effect of Basslink scenarios on power station and storage behaviour.
2. Running the TEMSIM model under a range of scenarios including no cable (0 MW), and a range of cable power ratings with equal transfer capabilities (300, 450, and 600 MW). Note that at the time when the model was run for the scoping exercise, the proponent had not been selected and the exact cable specifications were unknown.
3. Analysis of the hydrological outputs of TEMSIM to allow identification of those waterways affected by Basslink. This involved comparing the outputs of the Basslink cable scenarios with those for no cable (0 MW) and with historical data.
4. Identification, as far as possible, of the environmental and social issues associated with the waterways shown to be affected by Basslink.
5. Recommendations on studies to comprehensively evaluate environmental and social issues identified in Step 4.

The forecast annual Tasmanian system load, as calculated by forward load predictions to 2003 (when Basslink would come on line), was set at 1135 MW for all cases. This was taken from the System Controller 1998 planning statement as the official load forecast. Start storages for the model were determined by taking the storage levels at June 1999 (76%) and running SYSOP to predict the storage levels at January 1, 2003.

Results of the modelling showed that the most significant changes to Hydro Tasmania waterways would be downstream of the two major storages in the system, that is, downstream of Great Lake and Lake Gordon. Discharges out of both Poatina and Gordon power stations show the same predicted changes under Basslink compared to historic operational patterns. Notably, these changes are increased short-term variability in flow discharges, increased frequency of short duration (and weekend) shutdowns, and changes in the seasonality of flows. Additional to these two power stations, changes in the seasonal nature of discharges out of the John Butters Power Station in the King River catchment are indicated, as well as some increase in the already highly variable pulses of discharge.

Map 2.2 shows the locations of the three catchments and power stations likely to show changes under Basslink.



Map 2.2 Locations of Basslink-affected power stations, their catchments, and the catchments of the downstream rivers.

No significant changes are indicated by the modelled results for any of the lakes in the Hydro Tasmania generating system. TEMSIM modelling results suggest that average monthly lake levels for Lake Gordon, Great Lake and Lake Burbury are held somewhat lower with Basslink than their historical ranges (on average 1-2 m for Great Lake and Lake Burbury, and 3-4 m for Lake Gordon), and tend to fluctuate over a narrower range than historical. This is not considered to be significant, given that it is within the normal operating range for the lakes, and for the major storages presents only a very small change from the very large operating ranges (52 m for Lake Gordon, 21 m for Great Lake, 9 m for Lake Burbury). All existing obligations affecting lake level management in the Hydro Tasmania system will continue with or without commissioning of Basslink.

Detailed plots of these modelled changes for the four cable power ratings modelled in the initial scoping exercise are provided in Appendix 1.

Since the analyses for the Scoping Report were undertaken, the Basslink proponent was selected and more detailed cable specifications were then provided. Modelling runs since the scoping report have been for the 480 MW continuous power rating (up to 600 MW export, 300 MW import) proposed by National Grid International Limited (NGIL), and output from these are utilised in the further hydrological analyses presented in this report and remaining appendices.

An assessment of the validity of the conclusions of the Scoping Report, given updates to the TEMSIM model based on further model refinement and consideration of the exact cable specifications proposed by NGIL, is undertaken in the TEMSIM Sensitivity Study (Appendix 29 of this report series). The results, presented in Section 6 of this report, show no significant changes to the conclusions of the Scoping Report (Appendix 1) based on the further model refinements.

2.5 Environmental Investigations for Basslink

Based on the outcomes of the initial scoping exercise, showing increased short-term variability in flow discharges over the full power station range as well as seasonal changes for the Gordon, Poatina and John Butters power stations due to Basslink, a suite of environmental investigations was defined for the affected downstream river systems.

The following sections (3, 4 and 5) describe the methodologies and results of environmental investigations into the effects of the Basslink cable. Each section commences with a description of the relevant catchment and power scheme, and then presents details of the hydrological analyses comparing historical and Basslink hydrology at that power station. The hydrological analyses presented for each power station are based on runs of the TEMSIM model using the 480 MW continuous power rating as is proposed by NGIL.

Studies on the Gordon River (Section 3) address geomorphology, instream ecological health (macroinvertebrates, platypus, native water rats and fish), meromictic lakes, water quality, karst, cave fauna, riparian vegetation, terrestrial fauna, cultural heritage issues, public use issues and World Heritage Area values.

Environmental investigations on the waterways downstream of Poatina Power Station (Section 4) address geomorphology, instream ecological health, water quality, cultural heritage, terrestrial flora and fauna, public use issues and socio-economic issues.

Investigations downstream of the John Butters Power Station (Section 5) address geomorphology, water quality, instream ecological health, cultural heritage and public use issues in the King River, and water quality in Macquarie Harbour.

3 DOWNSTREAM GORDON POWER STATION INVESTIGATIONS

Section 3 begins with background information on the Gordon catchment and power scheme (Section 3.1).

Sections 3.2 to 3.7 present the outcomes of the environmental assessment of Basslink impacts on each of the major headers required for assessment in the Basslink Integrated Impact Assessment Statement:

Sec. 3.2 - Surface Waters (hydrology, water quality),

Sec. 3.3 - Land (fluvial geomorphology),

Sec. 3.4 - Groundwater (karst geomorphology),

Sec. 3.5 - Flora and Fauna (riparian vegetation, macro-invertebrates, fish, platypus and native water rats, terrestrial fauna, cave biota),

Sec. 3.6 - Estuarine Issues (meromictic lakes), and

Sec. 3.7 - Socio-Economic Issues (cultural heritage, visual amenity, public use and safety, industries affected and economic impacts).

Section 3.8 assesses the implications of Basslink on World Heritage Area values.

Section 3.9 summarises the investigations on the Gordon River, identifies Basslink issues, and proposes mitigation options.

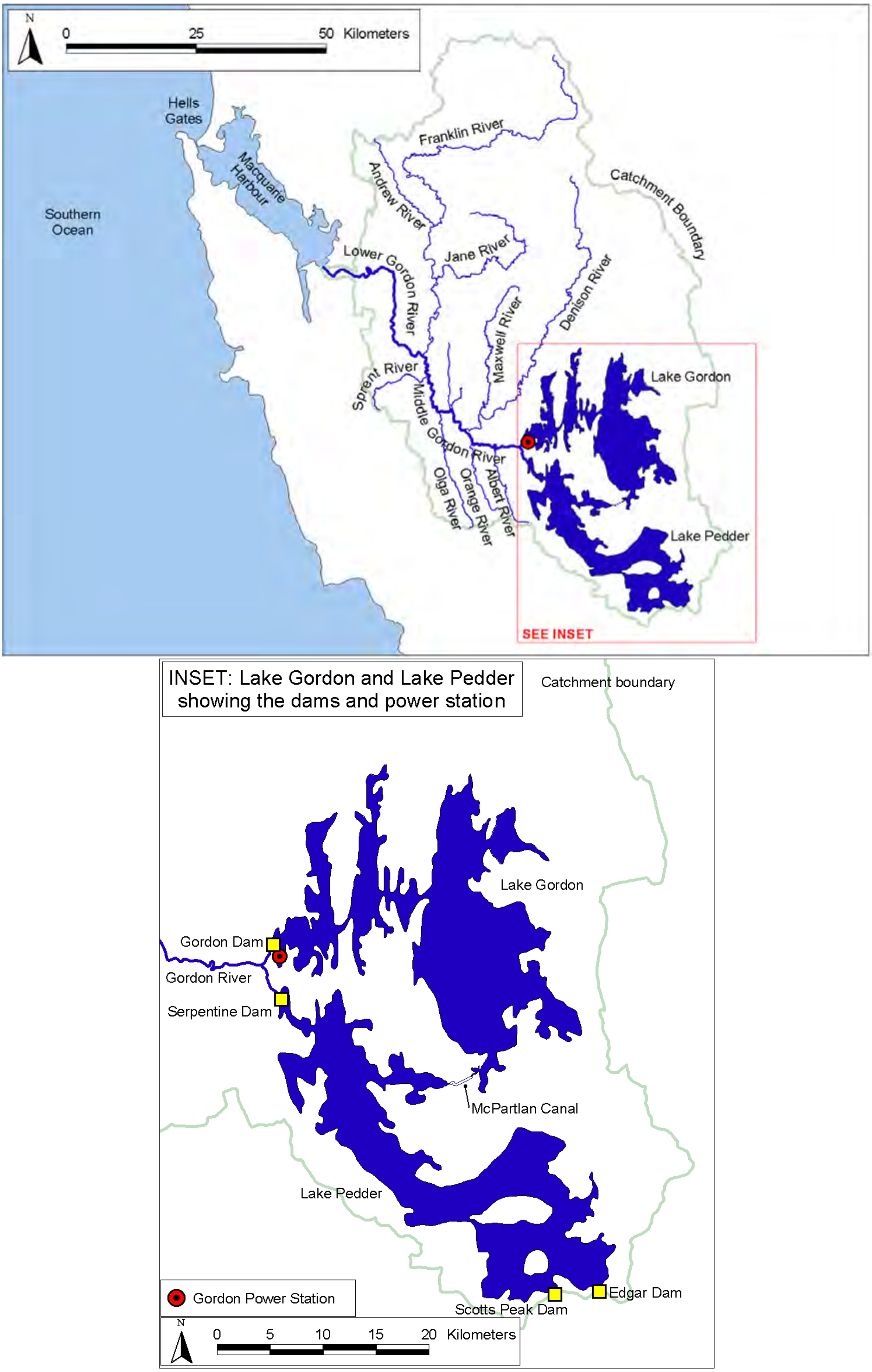
Section 3.10 presents the proposed Basslink monitoring program for the Gordon River.

3.1 Background Information on Gordon Catchment

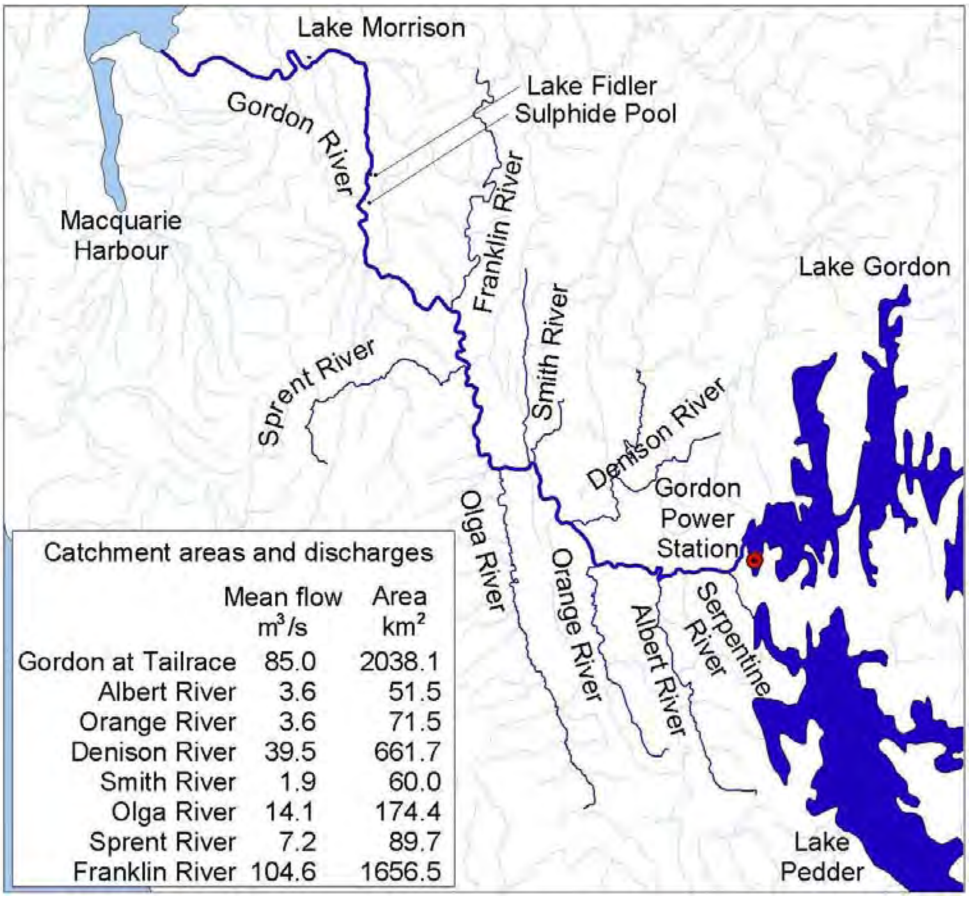
3.1.1 Gordon Catchment

The Gordon catchment is located in the southwest of Tasmania and covers an area of approximately 7,220 km^2. Of this area, approximately 2,000 km^2 drains into the two storages for the Gordon Power Scheme – Lake Gordon and Lake Pedder, shown in Map 3.1. Lake Pedder captures the upper section of the Huon River catchment (less than 10%) and diverts it into the Gordon Power Scheme.

The remaining catchment area of more than 5,000 km^2 is downstream of the Gordon Dam, and includes a number of major tributary rivers including the Denison, Olga and Franklin Rivers. Names and catchment areas of the major tributary rivers are shown in Map 3.2. The Gordon River downstream of the Gordon Dam is often divided into the Middle Gordon River (upstream of the Franklin River confluence) and the Lower Gordon River (downstream of the Franklin River confluence), and these river reaches are indicated on Map 3.1. The Lower Gordon River is an estuarine reach extending 38 km in length.



Map 3.1 Lake Gordon, Lake Pedder and the Gordon River



Catchment areas and discharges

	Mean flow m^3/s	Area km^2
Gordon at Tailrace	85.0	2038.1
Albert River	3.6	51.5
Orange River	3.6	71.5
Denison River	39.5	661.7
Smith River	1.9	60.0
Olga River	14.1	174.4
Sprent River	7.2	89.7
Franklin River	104.6	1656.5

Map 3.2 Downstream Gordon tributaries, mean discharges and catchment areas.

The principal uses of the Gordon catchment are hydro-electric power generation, wilderness activities, tourism and recreational uses. A township at Strathgordon is associated with the power development, but is also utilised by tourists and anglers.

The entire catchment downstream of the Gordon Power Scheme is within either the Franklin-Gordon Wild Rivers National Park or the South-West National Park. These national parks form part of the Tasmanian Wilderness World Heritage Area (TWWHA). There are some small tracts of Hydro Tasmania-owned land in the catchment. Most of the Gordon and Pedder catchments are zoned either wilderness or recreation/self reliant recreation in the TWWHA Management Plan. The primary land uses of the WHA are tourism and recreation associated with wilderness appreciation.

The geology of the Gordon catchment is predominantly Precambrian basement rocks, more than 1,000 million years old, as well as Paleozoic rocks including Ordovician limestones and sandstones, and Devonian-Silurian limestone-siltstone-shale sequences. These rocks are overlain by Quaternary sediments.

The dominant vegetation types in the Gordon and Pedder regions are *Eucalyptus simmondsii* and *Eucalyptus obliqua* wet forest, rainforest, buttongrass moor, and wet scrub. Rainforest and wet scrub occur mainly in the western part of the catchment, while buttongrass moors are located throughout the region.

Rainfall over the Gordon catchment ranges from 1,600 mm annually over the western coastline to over 3,200 mm at some points along the mountain ranges.

3.1.2 Gordon Power Scheme

The Gordon Hydro-Electric Power Development was approved by Tasmanian State Parliament in 1967. Three dams were constructed in 1971-72 to enlarge the original Lake Pedder and form the present Lake Pedder impoundment: Scotts Peak Dam on the upper Huon River, Serpentine Dam on the lower Serpentine River, and Edgar Dam across a low marshy area at Lake Edgar near Scotts Peak (see Map 3.1). Lake Gordon was formed in 1974 by the construction of the Gordon Dam across the Gordon River, upstream of the Serpentine River confluence. Lake Pedder and Lake Gordon are connected via McPartlans Canal, shown on Map 3.1.

One power station, the Gordon Power Station, was built for the scheme. The Gordon Power Station commenced operation in November 1977 with one generator, and the second generator became operational in 1979. The third of the three generators in the power station was brought on line in 1988. The three Francis generators each have a generating capacity of 144 MW. The long-term average electricity output from the power station is 157.6 MW, which is 14.1% of the long-term average output for the State.

Lake Gordon and Lake Pedder effectively operate as a single storage for the Gordon Power Scheme, with water transfers via McPartlans Canal. Lake Gordon has a surface area at full supply level of 278 km^2, a reservoir volume of 12,450 Mm^3, and an approximate depth at the dam of 137 m. Lake Pedder has a surface area at full supply level of 241 km^2, a reservoir volume of 2,960 Mm^3, and an approximate depth at the dam of 35 m. Lake Pedder has a small operating range of only 1.53 m, whereas Lake Gordon's potential operating range is almost 52m. The full supply level and normal minimum operating level for Lake Pedder is set by legislation to protect aesthetic values.

The Gordon Power Station is underground, and receives water from Lake Gordon through a cylindrical intake at the base of an 80-metre intake tower. The water falls 140 m through a vertical intake shaft and along a tunnel to power the generators. Water leaving the power station flows out along a 1.6 km tailrace to the Gordon River, where it flows approximately 78 km to Macquarie Harbour.

The Gordon Power Station is most commonly operated to provide 'base load' or 'step load'. The Gordon Power Station when generating base load discharges a constant flow all day, and when generating step load power is turned on at a particular time during the day, generates power at a constant load for a certain number of hours, and is then turned off or set to a different load for another time period.

During the relatively dry summer period, the Gordon Power Station runs generally as a base load station, with the number of generators in use depending on the daily electricity demand. At other times of the year, Gordon operates on step load, and generators are brought on or off depending on the changing electricity demand throughout the day.

Efficient load for all three generators at the Gordon Power Station equates to a power station discharge of approximately 210 m^3/s, and full capacity ('full gate') discharge is approximately 260 m^3/s. Efficient load and full capacity discharge varies depending on water levels in Lake Gordon.

3.2 Environmental Assessment of Surface Water Impacts

This section summarises environmental information on the Gordon River hydrology and water quality in relation to present status and potential Basslink changes.

3.2.1 Hydrology

A summary of hydrological information on Lake Gordon and the Gordon Power Station operations for historical operations and predicted Basslink changes is provided as Appendix 2 of this report series, Gordon River Hydrology Assessment.

3.2.1.1 Lake Levels

The historical record for Lake Gordon spans the period 1974 to 2000. The operating range for Lake Gordon has historically varied over 41 metres, between a monthly average of 266 m and 307 m ASL. Figure 3.1, Figure 3.2, Figure 3.3 and Figure 3.4 show comparisons of historical lake levels with Basslink lake levels as indicated by the TEMSIM model runs. All of these plots show that Basslink holds Lake Gordon levels lower than historical lake levels. Figure 3.3 shows that the seasonal fluctuation in Lake Gordon levels is similar between Basslink and historical, and that on average Basslink holds Lake Gordon lower than historical by approximately 3-4 m. Figure 3.4 shows that there is a large reduction in the range of Lake Gordon levels under Basslink compared with historical, with the 10th percentile level higher and the 90th percentile level lower than historical.

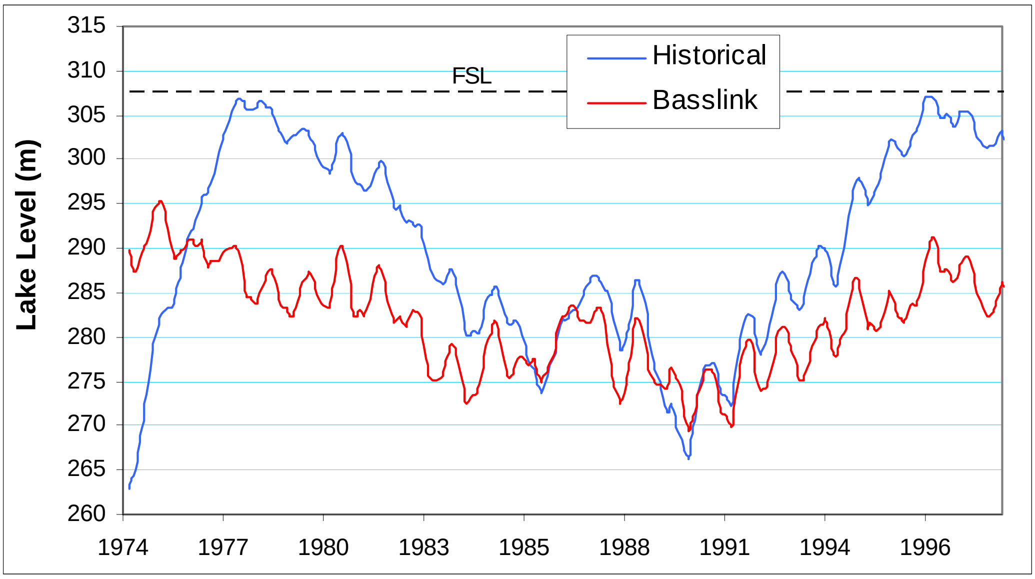


Figure 3.1 Lake level time series plot for Lake Gordon

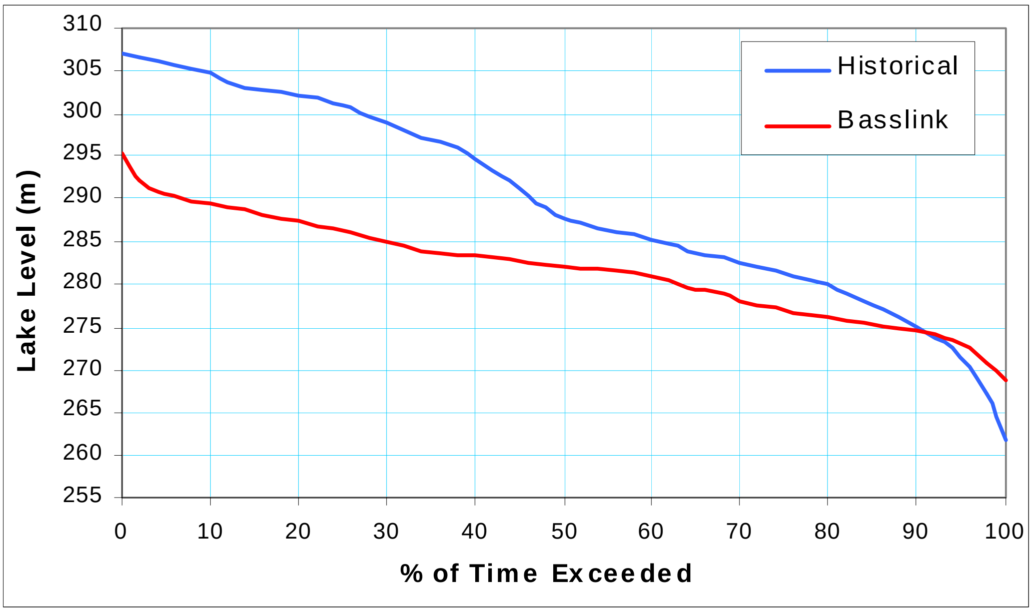


Figure 3.2 Lake level duration plot for Lake Gordon

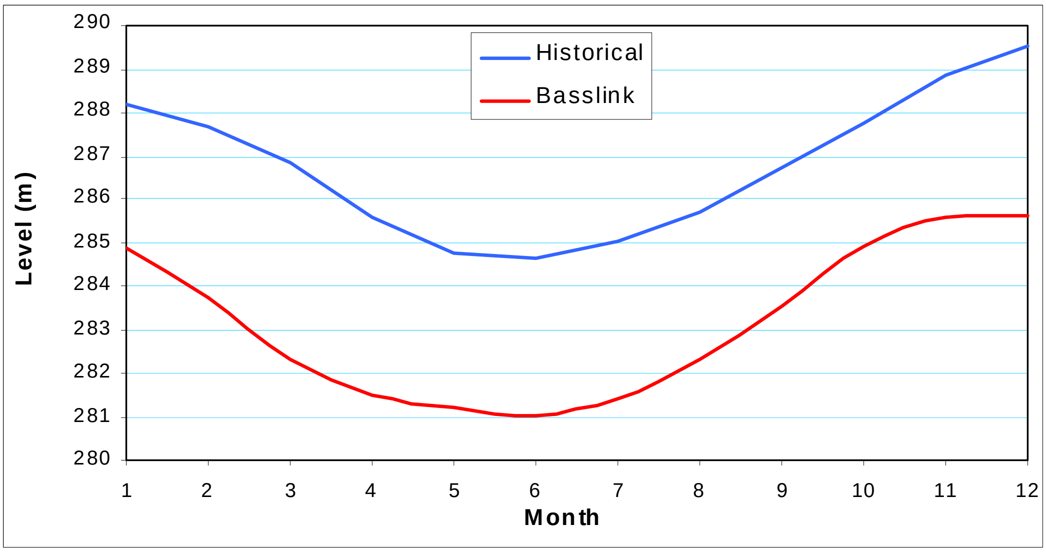


Figure 3.3 Average monthly lake levels for Lake Gordon

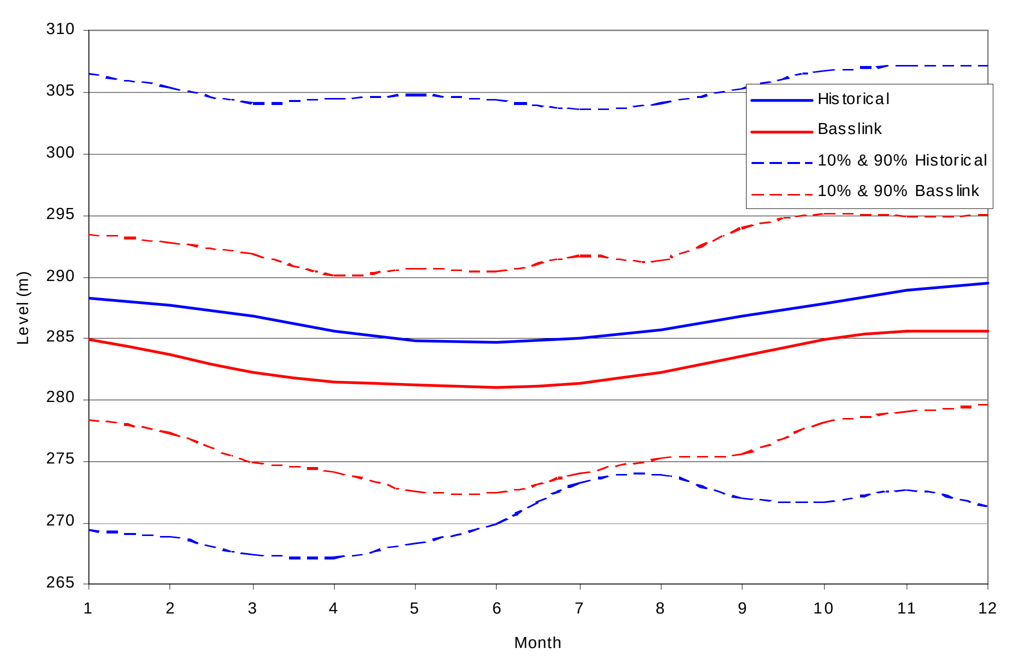
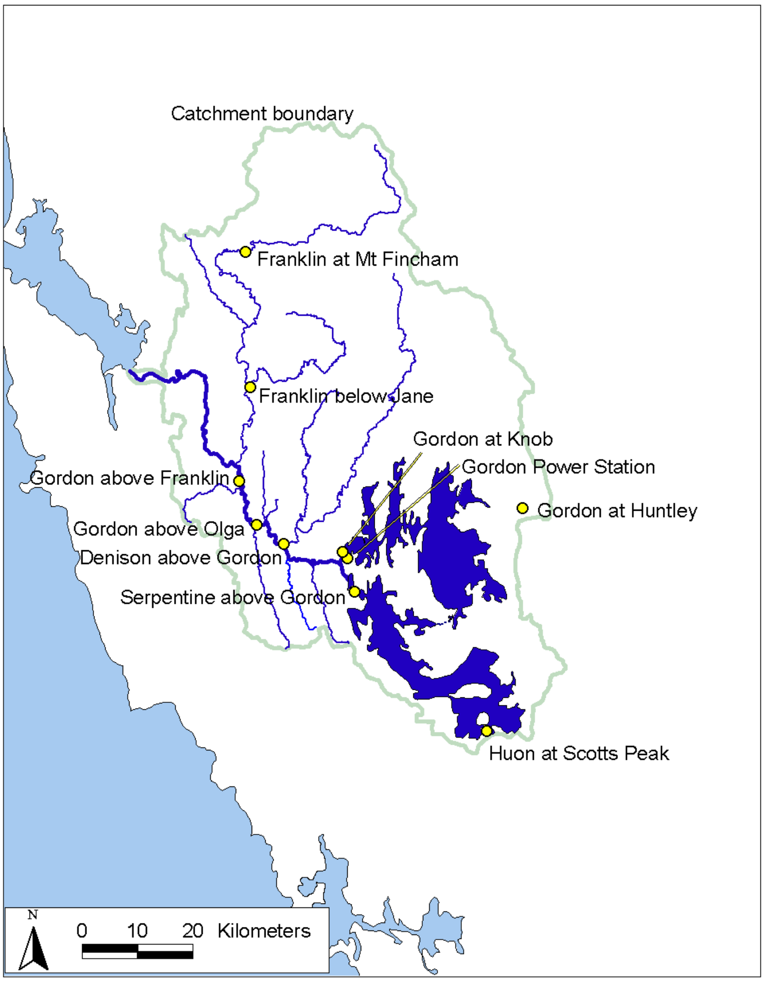


Figure 3.4 Mean, 10th and 90th percentile levels for Basslink and Historical scenarios

3.2.1.2 Power Station Discharges

Map 3.3 shows the locations of historical and existing hydrological sites in the Gordon.



Map 3.3 Gordon River Hydrological Sites.

Time periods for data available from each hydrological monitoring station are shown in Figure 3.5.

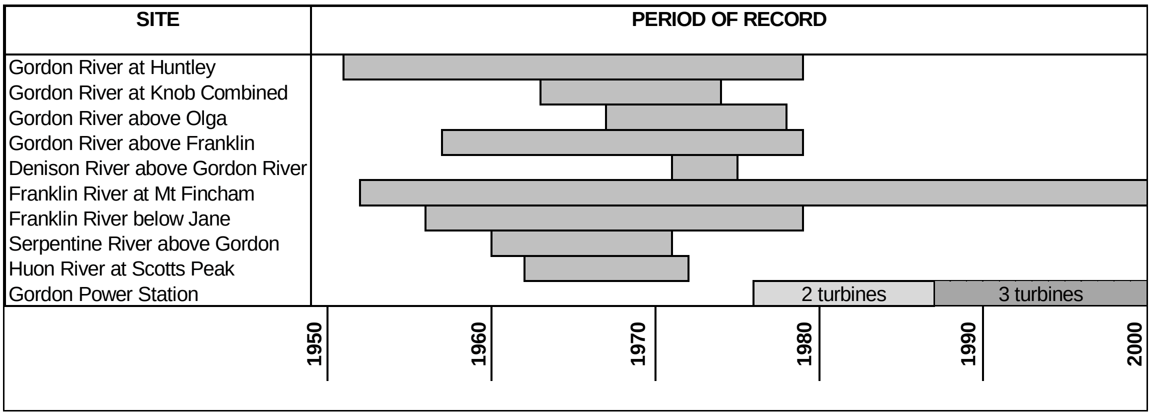


Figure 3.5 Availability of historical hydrological data in the Gordon River

Figure 3.6 and Figure 3.7 show time series plots for the Gordon Power Station during a dry year (1989) and a wet year (1996) for historical operations and Basslink. Figure 3.8 shows a comparison of historical and Basslink monthly median flows for the period 1989-1998. Notable differences between historical and Basslink patterns which are evident from these plots are the increased on-off operation of the power station, and more consistent and higher discharge periods in winter than in summer under Basslink compared to historical. Under Basslink there is an increased occurrence of weekend shutdowns of the power station. Basslink operation of the power station shows higher than historical flows during the summer months, and a bimodal monthly median flow pattern with a peak in summer and winter that is most pronounced during wet years.

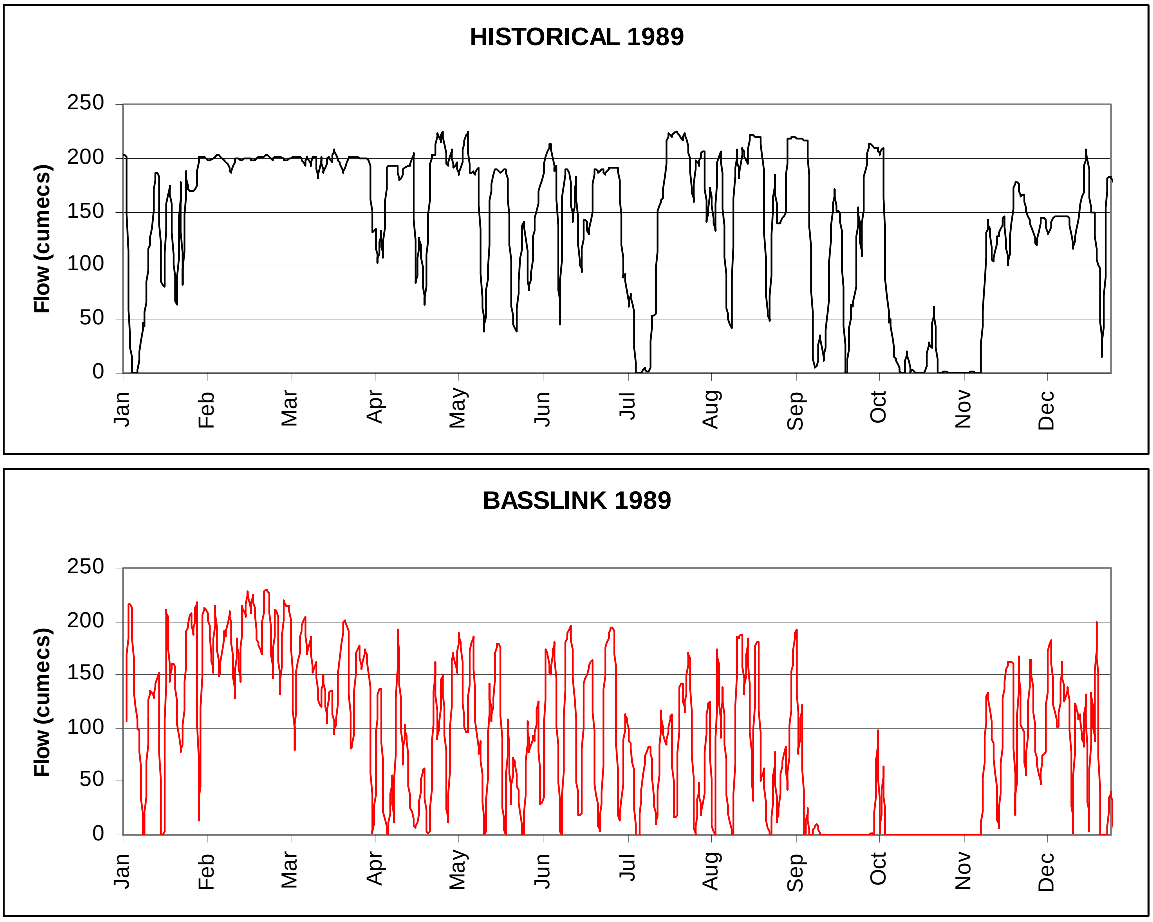


Figure 3.6 Annual time series at the Gordon Power Station for a dry year (1989) using daily averaged data

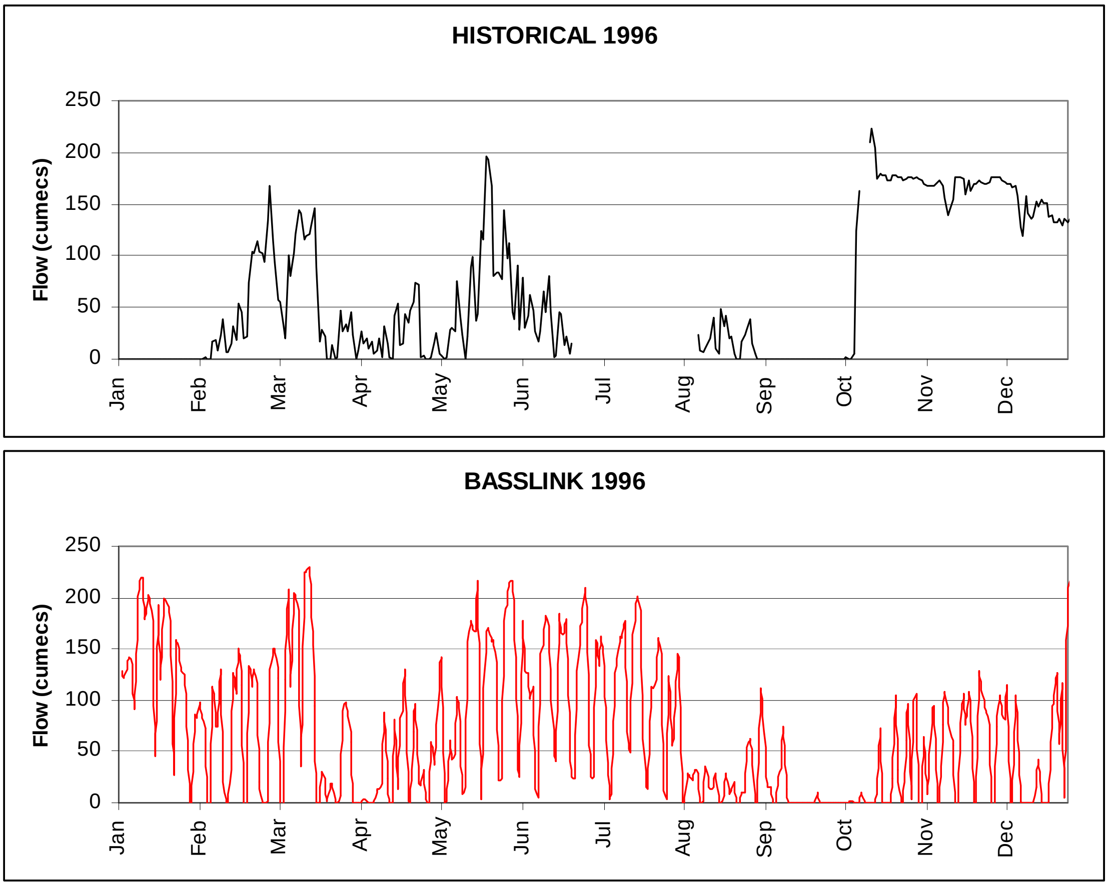


Figure 3.7 Annual time series at the Gordon Power Station for a wet year (1996) using daily averaged data

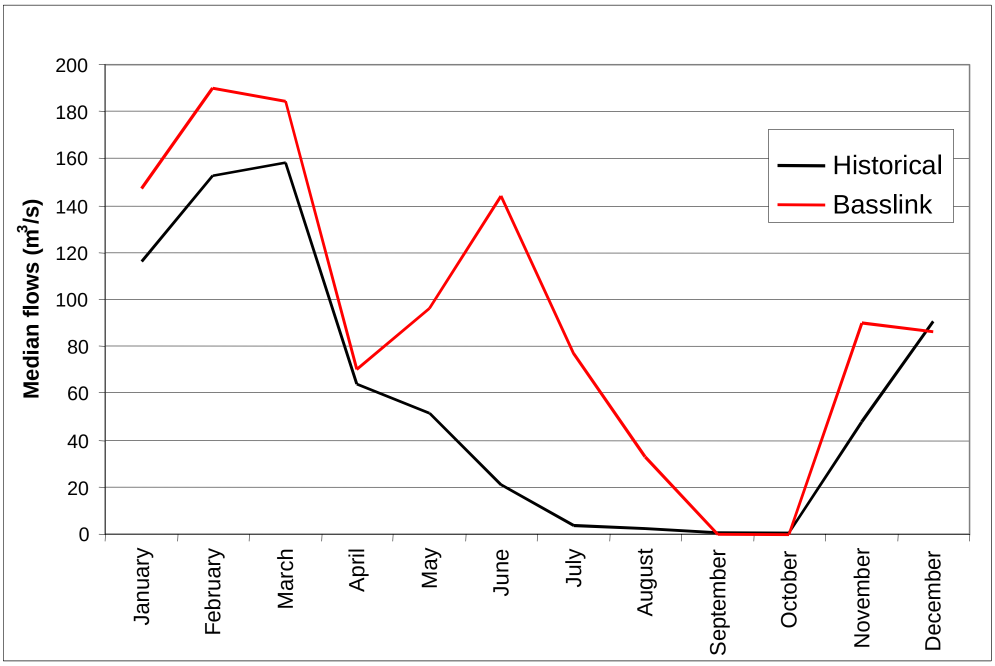


Figure 3.8 Monthly median flows from the Gordon Power Station

Table 3.1 shows summary statistics comparing actual and simulated hourly flow records at the Gordon Power Station, using data from 1997-98.

Table 3.1 Comparison of Actual and Simulated Daily Flow Records at the Gordon Power Station using Hourly Data (1997-1998)

STATISTICS	HISTORICAL OPERATION OF POWER STATION [1]		BASSLINK OPERATION OF POWER STATION	
Mean flow (m^3/s)	116		115	
Annual Mean Minimum Flow				
1 Hour Minimum (m^3/s)	0		0	
7 Day Minimum (m^3/s)	6		0.3	
Annual Mean Maximum Flow				
1 Hour Maximum (m^3/s)	245		249	
7 Day Maximum (m^3/s)	206		229	
The Number of Annual Events	Flow	No. Events	Flow	No. Events
-Greater than mean flow	116 m^3/s	219	115 m^3/s	297
-power station shutdown	0 m^3/s	73	0 m^3/s	254

[1] Record contains missing values.

Table 3.1 is based on hourly data, of which the years 1997-98 are available for the Gordon Power Station. Summary statistics based on the longer record of daily data were not adequate, particularly in showing the number of power station discharge or shutdown events, as many of these events are of less than 24 hours duration. Table 3.1 shows:

- Mean flows from the Gordon Power Station are similar (~115 cumecs) between historical (1997-98) and predicted Basslink operations.

- There are no significant changes in the mean minimum or mean maximum flows from the power station between historical and predicted Basslink operation.

- The average annual number of discharge and zero events changes significantly, with an increase from 219 to 297 discharge events greater than the mean flow, and an increase in the number of shutdown events from 73 to 254 each year. The disproportionate increase in shutdown events with Basslink compared to discharge events is because under historical operations the power station frequently switches between the number of generators (explaining the currently high number of release events greater than the mean flow), but under historical conditions it does not switch off as often as predicted to occur for Basslink.

An analysis of the duration of discharge events and zero discharge (shutdown) events showed an increase in duration of 2-6 hour and in 24 hour shutdown events under Basslink, and in 2-24 hour discharge events greater than the mean flow, compared to historical operations.

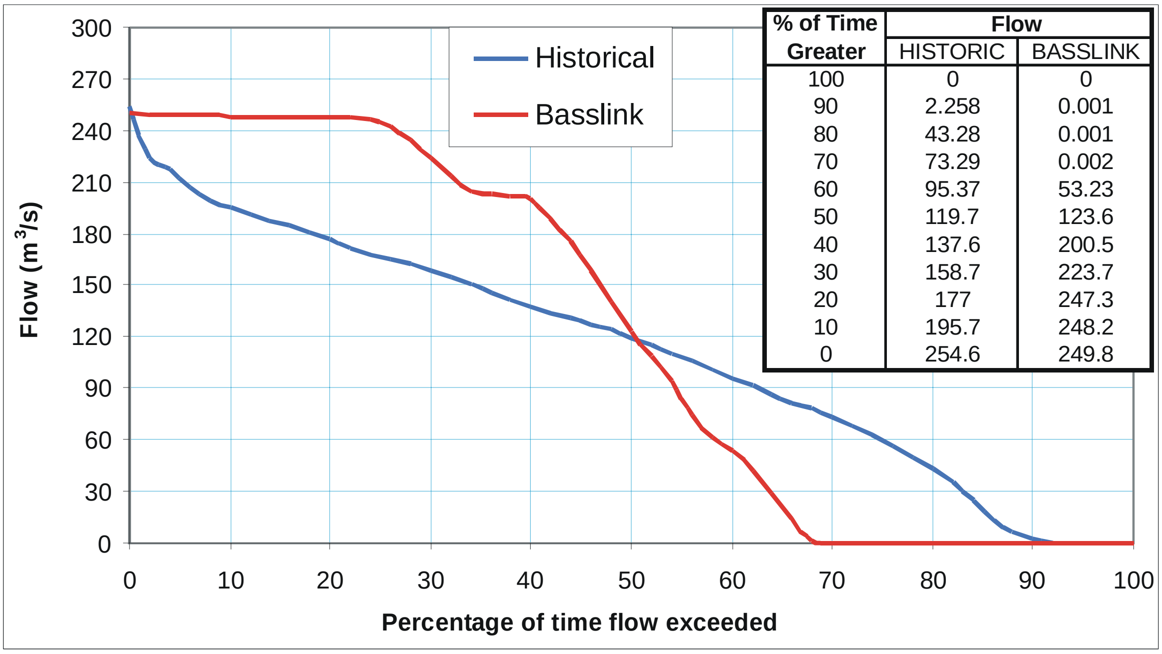
The time series plots indicated an increase in occurrence of weekend shutdowns with Basslink, and this was analysed more closely to see if this increase could be quantified. Table 3.2 shows that the number of weekend shutdown events does definitely increase with Basslink, most significantly with weekend shutdown events of 12-24 hours duration which increase at least six-fold with Basslink. This is attributed to lower Victorian prices expected on weekends, and thus the reduced use of the Gordon Power Station at these times.

Table 3.2 Assessment of Historical versus Basslink Weekend Shutdowns of Gordon Power Station

Period (hours) of power station shutdown	No. of events in 75 years of weekends[1]	
	Historic	Basslink
12-18	61	400
18-24	184	1041
24-36	75	63
36-48	88	99

[1] This analysis involved comparison of SYSOP with TEMSIM runs.

Historical and Basslink flow duration curves for the Gordon Power Station, based on hourly data, have been plotted in Figure 3.9. Figure 3.9 shows that under Basslink, Gordon Power Station discharges greater than 150 cumecs occur much more often than historically. In this case, the assessment of historical patterns is limited to 1997 and 1998, which are the only years for which hourly data is available.



% of Time Greater	Flow	
	HISTORIC	BASSLINK
100	0	0
90	2.258	0.001
80	43.28	0.001
70	73.29	0.002
60	95.37	53.23
50	119.7	123.6
40	137.6	200.5
30	158.7	223.7
20	177	247.3
10	195.7	248.2
0	254.6	249.8

Figure 3.9 Flow Duration Curves from Gordon Power Station under Historic and Basslink Operation (Hourly Data, 1997-98)

The historical operations of the Gordon Power Station during 1997 and 1998 were closely examined, in an effort to understand the considerable difference between historical and Basslink discharges greater than 150 cumecs. It was found that during 1997 and 1998 output from the Gordon Power Station was limited by generator and transmission line constraints. The transmission lines and generator operations are subject to continual upgrades and refinements that periodically impose constraints on power station output.

The data presented in Figure 3.9 are also influenced by the bias of the TEMSIM model towards full power station discharge rather than one or two generators operating. This characteristic of the TEMSIM model was discussed in Section 2.3.2, and leads to an over-estimation of discharges using all three generators at the Gordon Power Station under a Basslink operating regime.

As of the time of writing of this report, the majority of the generator and transmission constraints which limited output during 1997-98 have been removed, and the Gordon Power Station at present is more capable of generating at full capacity.

With the aim of taking a conservative approach to these Basslink environmental investigations, the Gordon River researchers were presented with the hydrological changes between historical and Basslink which are shown in Figure 3.9. As a consequence, many of the research conclusions seen in the following sections link Basslink to the environmental impact that would result if it were fully responsible for the increase in the frequency of full capacity discharges. The projected environmental implications of increased full capacity discharges are presented in the following sections, but the reader must bear in mind that they are very likely to be over-estimated.

3.2.1.3 Extent of Downstream Hydrological Influence of Power Station Operations

As described in Section 3.1, there are significant tributary inputs downstream of the power station (see Map 3.2), and the Lower Gordon River is tidally influenced. As a consequence, flows in the Lower Gordon River are far less influenced by power station operations than the Middle Gordon River. Rainfall and tidal influences are predominant in the Lower Gordon River, as shown in Figure 3.10. This figure shows power station discharges over a three month period during 2000, along with flows in the Lower Gordon River (‘Gordon b/l Franklin’ in Figure 3.10, shown as Site 39 on Map 3.4), tributary inflows (‘natural pickup’) between the power station and Lower Gordon River site, and rainfall at Strathgordon. From this figure, rainfall and tidal cycles are clearly seen to be significant influences on flows downstream of the Franklin River.

Because of the minimal power station influence in the Lower Gordon River, the Basslink investigations downstream of the Gordon Power Station were for the most part restricted to the Middle Gordon River. The exceptions to this were the studies of Macquarie Harbour water quality and the Gordon River meromictic lakes. Macquarie Harbour water quality was assessed because both the Gordon and John Butters Power Stations are predicted to have altered operating regimes due to Basslink, and these two power stations regulate the major riverine inflows to Macquarie Harbour. The meromictic lakes study was undertaken to further understand the relationship of power station operations with maintenance of meromixis in these lakes, and was a specific requirement of the JAP IIAS Guidelines.

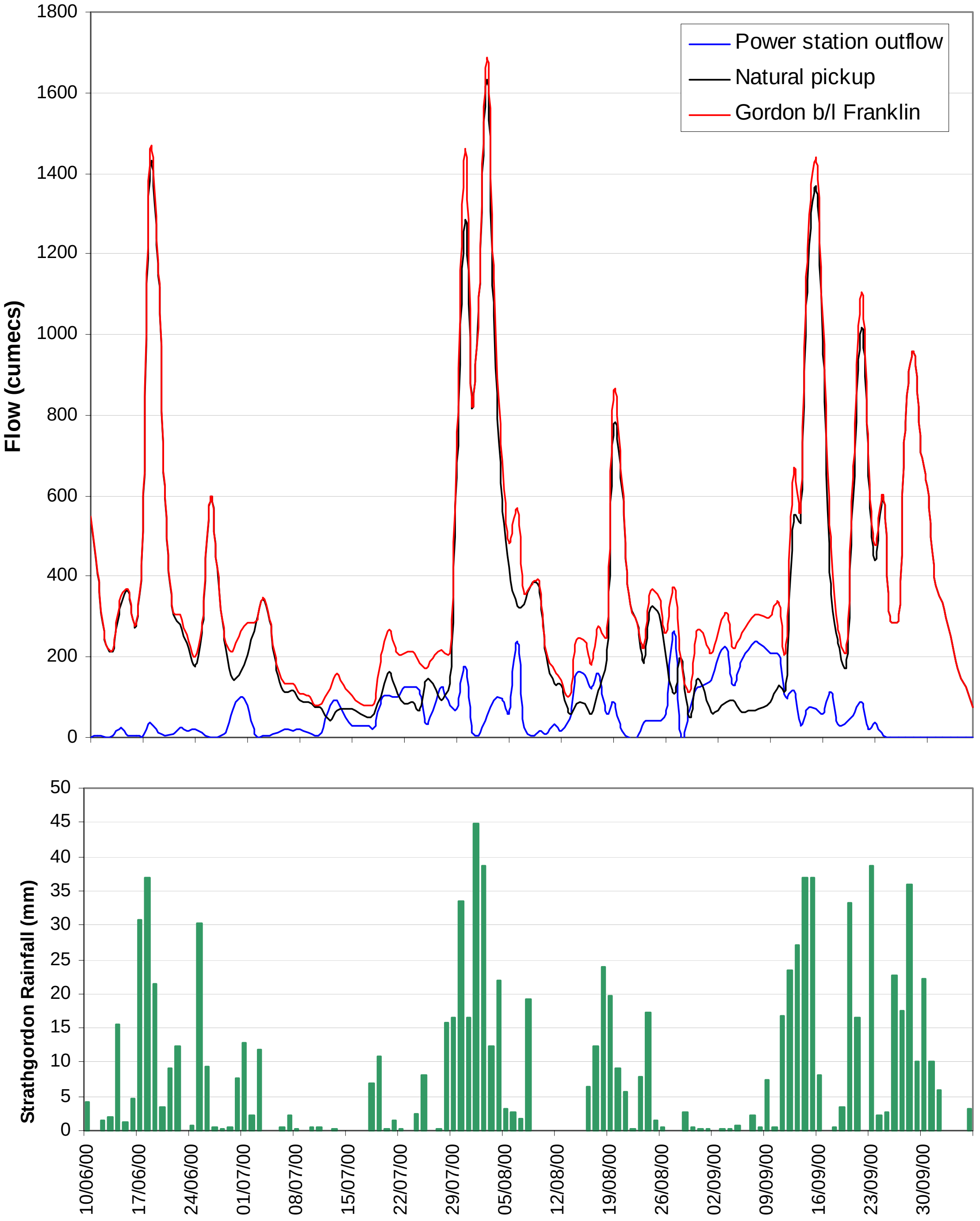
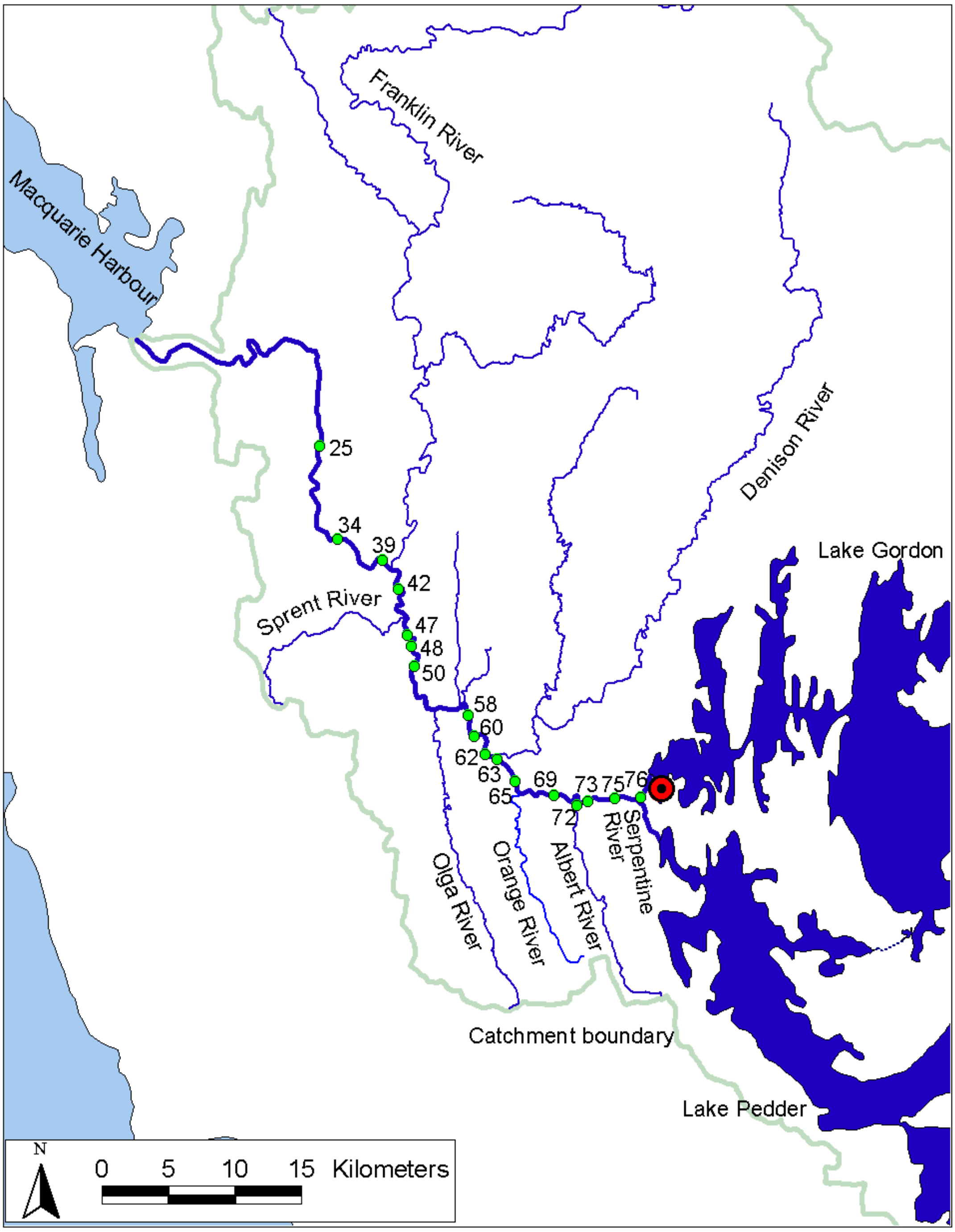


Figure 3.10 Influences on Flows in the Lower Gordon River

3.2.1.4 Downstream Propagation of Power Station Discharges

The propagation of power station discharges downstream of the power station was analysed as part of the 2000 investigations for this study. A four day power station shutdown in March 2000 was examined to assess lag times for the start of water level drops and rise at downstream sites, the time taken to drop at these sites, and the water level change. Seven sites were examined for these analyses, shown in Table 3.3, with the site locations in this table indicated on Map 3.4. The monitoring sites shown on Map 3.4 are referred to throughout Section 3 of this report. They are numbered according to conventional river research site numbering, with 0 km being at the Gordon River mouth, and Site 78 being at the power station tailrace.



Map 3.4 Gordon River Site Numbers for Environmental Investigations.

Table 3.3 shows that during the 3-7 March 2000 power station shutdown water levels downstream of the power station varied between a range of 1.67 and 4.12 m. Note that this exercise was undertaken during dry weather, when inflows from the tributaries were low. It takes more than 24 hours after the power station turns off for water levels to fully drop downstream of the Franklin River confluence (Site 39).

Table 3.3 Lag times along Gordon River during outage from 3-7 March 2000 at Gordon Power Station

(note all times are in hours)	***Gordon Power Station Shutdown***		***Gordon Power Station Turn On***		
Site	*Lag time in start of drop**	*Time taken to drop*	*Lag time in start of rise*	*Time to rise*	*Water level change (m)*
75	0.25	3.00	0.25	0.75	2.23
72	1.00	5.00	1.25	1.50	3.54
69	1.25	7.00	1.50	2.00	4.12
65	1.75	9.00	2.25	2.75	2.74
62	2.00	10.50	3.00	3.50	2.83
47	3.50	15.00	7.00	7.00	2.63
39	4.00	24.75	8.00	7.50	1.67

To provide a comparison with potential Basslink operation of the Gordon Power Station, a simulated on-off operating pattern was conducted during August 2000. The succession of shorter duration on-off events made very little difference to the water level range within 13 km of the tailrace (above the Denison River), but downstream of the Denison River (Site 65) showed the range of water level fluctuations dampened by as much as 0.5 m.

Table 3.3 shows that there is still some water level fluctuation in response to power station operation seen at Site 39, just downstream of the Franklin River confluence. This power station influence diminishes within a short distance further downstream, as the estuarine reach broadens considerably. Figure 3.11 compares water level fluctuations between June and October 1999 at the Gordon downstream of the Franklin River confluence (Site 39) with the Gordon River at Lake Fidler (Site 25 on Map 3.4). Power Station discharge patterns appear to have only a small influence on water levels in the Gordon River at Lake Fidler.

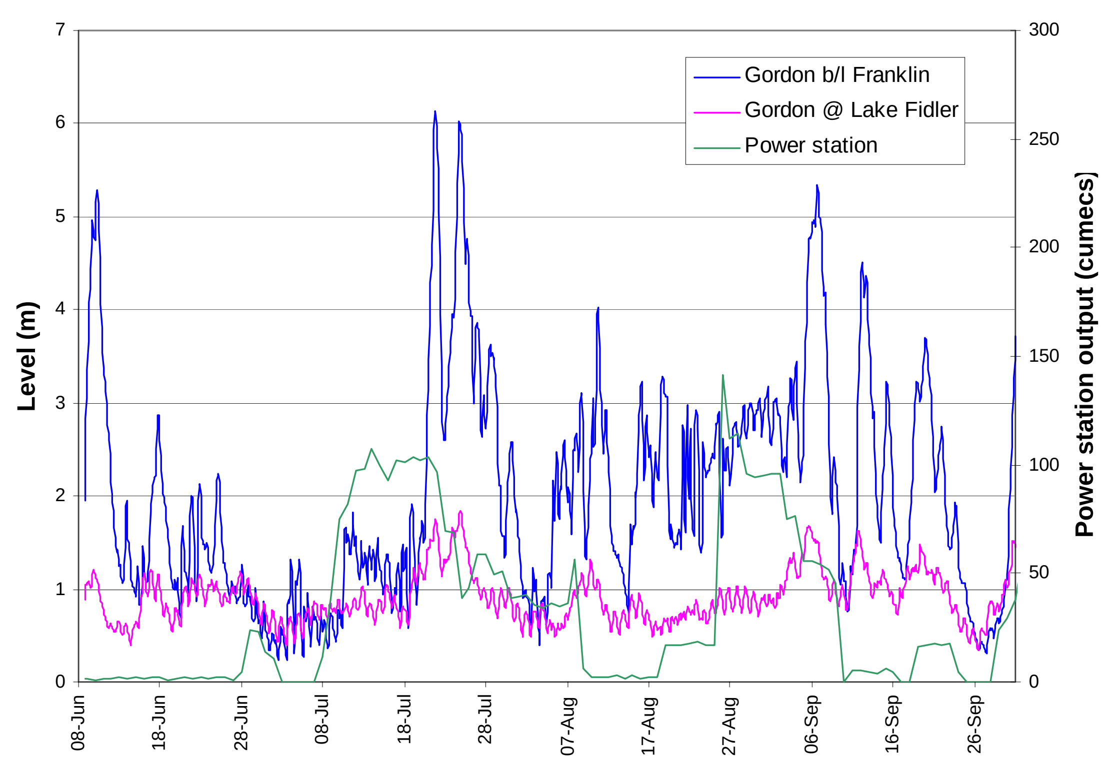


Figure 3.11 Water level fluctuations in the Gordon River downstream of the Franklin River and at Lake Fidler.

3.2.1.5 Summary of Gordon River Basslink Hydrological Changes

In summary, under Basslink for the Gordon Power Station the most significant changes are a significant increase in the number of on-off events in a given year, and a slight seasonal shift in power station discharges. The projected increase in the occurrence of discharges greater than 210 cumecs can not fully be attributed to Basslink, as it reflects load constraints on the period of historical data; to be conservative, however, associated environmental impacts with such an increase are included in the following sections. Note that there is no increase in the maximum release capacity of the power station, as this is limited by the generator capacities. Rates of river level rise and fall at the power station will not change due to Basslink, although attenuation downstream may change with increased on-off operation.

The information in Appendix 2, the Gordon River Hydrology Assessment, was made available to all of the Gordon River Basslink researchers, plus any supplementary hydrological information which they requested during their studies. Several of the Gordon River appendices present more detailed and purpose-specific hydrological data and analyses to add understanding to the particular discipline under assessment.

3.2.2 Water Quality

3.2.2.1 Methodology

Water quality in Lakes Gordon and Pedder and in the Gordon River was examined by Koehnken, and the full details are available in Appendix 3 of this report series. Historical data for the lakes and river was examined, and additional data was collected for this study from the river and its tributaries. Two water quality surveys were conducted in March 2000 to assess power station on and power station off conditions in the Gordon River. Additionally, water quality probes were deployed to record temperature, dissolved oxygen, conductivity and pH during August 2000, to capture the power station on-off Basslink simulation sequence described in Section 3.2.1.4. Appendix 3 provides a systematic assessment of the implications of Basslink on all of the key indicators for Water Quality Objectives provided by the Department of Primary Industries, Water and the Environment (DPIWE).

3.2.2.2 Lake Gordon

The quality of the waters flowing into Lakes Gordon and Pedder is considered to be excellent, and not expected to change under Basslink.

Thermal gradients in the Lake Gordon impoundment result in lake stratification, and subsequently differences in water quality depending on lake depth and time of year. Lake Gordon surface levels can fluctuate by more than 50 m, and this has necessitated a fairly low elevation intake for water feeding into the power station. Therefore there can be large variation in the relative level of the intake with respect to surface of the lake.

Under circumstances of a high lake level during the warmer summer months, release of cooler de-oxygenated water from deep within Lake Gordon to the power station can occur. Dissolved oxygen (D.O.) concentrations are reduced to less than 6 mg/L (the ANZECC (1992) threshold) at a depth of 35-40 m under summer conditions, so there is a risk of discharging low D.O. water through the power station when lake levels are higher than 290-295 m. This has occurred 45-50% of the time through the historical record of lake level variations, but because Lake Gordon levels cycle up and down over periods of years, the occurrence has fallen into only two time periods: 1977-1982, and 1994-2001.

Metal concentrations increase with depth in Lake Gordon, but concentrations discharged from the power station are low and similar to influent rivers. Nutrient concentrations are low and not an issue for these waters.

Mercury levels have been closely examined in a PhD thesis (Bowles 1998). Total mercury concentrations determined by Bowles (1998) were all <0.01 µg/L. This is well below the ANZECC (1999) draft guidelines of 1.0 µg/L for the protection of human consumers of aquatic foods, and below the ANZECC (1999) most stringent guideline for inorganic mercury of 0.06 µg/L.

3.2.2.3 Middle Gordon River

3.2.2.3.1 Dissolved Ions

There is a clear water quality ‘signature’ from the power station in the downstream Gordon River, characterised by low alkalinity, calcium and magnesium. When the power station is not discharging, these parameters are elevated reflecting the widespread carbonate rock in the tributary catchments. The relative contributions of these parameters vary with power station discharge, distance from the power station, and tributary inflows.

Conductivity readings, which reflect the concentrations of dissolved ions in the water, varied during the August Basslink simulation sequence between 70 µS/cm^2 with the power station off (reflecting tributary inputs) to 40 µS/cm^2 with the power station on (showing dilution with Lake Gordon water of lower ionic composition). Draft ANZECC (1999) guidelines for conductivity recommend that increases should be less than 60 to 110 µS/cm^2 for freshwater lakes and reservoirs and upland rivers. Although conductivity varies with power station operations, there are no particular water quality issues related to conductivity in the Middle Gordon River.

3.2.2.3.2 Dissolved Oxygen

The ANZECC (1992) guidelines for dissolved oxygen (D.O.) is 6 mg/L. With the power station on, D.O. concentrations increase slightly between the intake and the tailrace, and very rapidly once discharged from the tailrace. Air injection into the power station generators increases D.O. concentrations by 2-6 mg/L. While air injection is a management tool used to increase the efficiency of individual generators under intermediate power loads, it can have an environmental benefit.

The high flow velocities and turbulence in the Middle Gordon River immediately downstream of the power station has a large influence on the D.O. concentrations of water released through the power station. A water quality survey in March 2000, when D.O. was 5 mg/L at the intake, showed D.O. increased to 6 mg/L at the tailrace and increased to ambient concentrations within 1.5 km downstream of the tailrace.

During the August 2000 power station Basslink simulation, water released from the power station had a D.O. of about 8 mg/L. This increased to 12-13 mg/L by the time it reached the Splits. When the power station was turned off during this on-off sequence, D.O. levels at the downstream sites dropped by approximately 1 mg/L.

In conclusion, due to air injection and high levels of turbulence immediately downstream of the power station, discharge of de-oxygenated water into the Middle Gordon River is not an issue. There are slight downstream fluctuations in D.O. levels under a Basslink scenario of increased on-off operation, but these are not considered significant from a water quality or a biological (P.Davies, *pers.comm.*) perspective.

3.2.2.3.3 Gas Supersaturation

The potential for gas supersaturation downstream of the Gordon Power Station was considered in this study. Gas supersaturation occurs when total gas pressure in a waterbody exceeds 105% of atmospheric pressure, due to physical mixing of the water and gasses. Of the total gas pressure, oxygen actually plays only a small part, because nitrogen is the major component of air (78%).

Gas supersaturation was considered possible because the increase in oxygen saturation (increased D.O. concentrations) is due to the uptake of air during turbulent flow in the river. Elevated total gas pressure leading to conditions of gas supersaturation is often evident by the very distinct effects on fish known as gas bubble disease. However, fish caught in the Gordon River show no symptoms of gas bubble disease, and assessment of this issue was not pursued further.

3.2.2.3.4 Temperature

The present temperature regime of the Middle Gordon River is strongly influenced by water discharged from the power station, which varies between 8-11°C on an annual basis, with the exception of occasional spikes. In contrast, an unregulated Tasmanian West Coast river for which data are available, the Savage River, has temperatures ranging much more widely, from 5-6°C in winter to up to 20°C in summer.

The temperature of the water released from the Gordon Power Station, particularly during summer months, does not rise quickly in the downstream environment. During the March 2000 high flow survey, water temperature was 10.0°C at the intake, 10.6°C at the tailrace, 10.8°C at the Splits, 11.1°C downstream of the Denison River, and 11.2°C at Warners Landing (34 km upsteam of Gordon River mouth, Site 34 on Map 3.4). On this occasion the major tributary rivers had water temperatures ranging between 14.0 and 14.6°C, similar to temperatures measured in Savage River at this time of year.

The on-off Basslink simulation of the power station in August 2000 showed temperature fluctuations in the Gordon River increasing in range with distance downstream from the power station. The power station on-off sequence showed changes in water temperature of 0.5°C between on and off conditions just 1.5 km downstream of the tailrace. Changes in water temperature of 1.5°C between on and off conditions were measured below the Denison River, where the Denison was bringing in water of a more seasonal water temperature when the power station was off.

The ANZECC (1999) draft guidelines for the protection of aquatic ecosystems compare water temperatures in a modified waterway with a reference waterway. These guidelines state that median seasonal temperatures should be maintained below the 80th percentile of the reference condition in the case of increased temperature regimes, or above the 20th percentile of the reference condition in the case of reduced temperature regimes. Savage River is an unregulated river on the West Coast for which continuous water temperature data is available, and so is used here for comparison, although it is not an established reference site. Using the available Savage River data leads to target summer temperatures for the Gordon River of more than 15°C, and winter temperatures of less than 8.5°C.

3.2.2.4 Management Issues and Mitigation Options

3.2.2.4.1 Management Issues

Under existing conditions, the main water quality management issues are the possible discharge of low D.O. and low temperature water from the power station during summer months. Low D.O. water tends to rapidly re-oxygenate downstream of the power station, so is not a management issue. The temperature range in the Middle Gordon River is less than targets determined as outlined by the ANZECC (1999) guidelines.

Under Basslink, Lake Gordon is expected to be maintained at lower levels than under present operating conditions (see Figures 3.1 to 3.4). This means that water will be drawn from relatively higher in the water column for use in the power station. This water will have higher D.O. concentrations, and warmer temperatures during the summer period.

More frequent on-off operation of the power station under Basslink will cause more frequent water temperature fluctuations in the downstream river system as compared to existing conditions. However water temperatures released through the power station will be higher during the summer period under Basslink, and this will reduce the temperature differences between the Gordon River and the tributaries compared to existing conditions.

On a seasonal basis, water temperatures in the Gordon River would be expected to fluctuate between about 12-15°C in summer, and between 6-9°C during winter, under Basslink. These temperature ranges assume a 1°C increase from Basslink due to lower lake levels during summer, and an additional increase from greater tributary input. The projected winter reduction in temperatures under Basslink compared to at present is due to frequent, short duration tributary input. Smaller temperature fluctuations are expected during the spring and autumn with Basslink, when lake and tributary temperatures are similar.

Under Basslink, median flows are expected to be reduced during early summer and autumn compared to existing conditions, which will mean that Gordon River water temperatures will more closely reflect tributary water temperatures as the proportion of power station water is less. This could be beneficial to instream biota which rely on seasonal temperature signals as triggers for physiological processes such as reproduction and migration, and show increases in metabolism, growth and productivity with warmer temperatures.

3.2.2.4.2 Mitigation Options

There are no management issues related to Gordon River water quality arising from Basslink which require mitigation. In fact, the expected Basslink changes to water quality provide some benefits for existing conditions.

The main water quality issue related to existing operations is the release through the Gordon Power Station of suppressed summer and slightly elevated winter temperatures into the Gordon River, as compared to ambient. Lowering lake levels is a management strategy which could be adopted to result in the intake through the power station of more oxygenated and warmer water during summer months. This is anticipated to occur under Basslink.

The risk of de-oxygenated water being released through the power station in summer when lake levels are high is also reduced under Basslink by the lower lake levels. Water released through the power station has been shown to be naturally aerated within a short distance downstream of the power station so no further actions are required.

3.2.2.4.3 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures that may be established. The following sections summarise:

- the monitoring considerations of the individual researchers; and
- the Basslink-related options arising from those considerations.

3.2.2.4.3.1 Researchers’ Monitoring Considerations

The monitoring considerations raised in the Water Quality Assessment (Appendix 3) included continuing the monitoring program presently in operation as part of Hydro Tasmania’s Waterway Health Monitoring Program (WHMP). This program involves regular water quality profiles in Lake Gordon and continuous recording of water quality downstream of the power station. Additional monitoring of total gas pressure during high flow conditions in the Gordon River downstream of the power station was also suggested to ascertain whether conditions of gas supersaturation ever occur. The continued monitoring of temperature at river level recorder stations both upstream and downstream of the confluence with the Gordon and Denison rivers was also suggested.

3.2.2.4.3.2 Basslink-related Monitoring Options

The WHMP regime for Gordon water quality will be continued before, during and after the transition to Basslink operational conditions, and should be sufficient to detect any unforeseen effects and track long-term water quality trends.

While the total gas pressure monitoring suggestion is presented in Appendix 3 as precautionary only, gas supersaturation, if present, has the potential to cause the death of fish in downstream waters. It is unknown, at this stage, whether Basslink operations would contribute to a higher incidence of gas supersaturation. Additional investigations are required to determine total gas pressures in the Middle Gordon River. If gas supersaturation is prevalent, appropriate sensors will be located at the tailrace, and in the downstream waterway. The tailrace values will indicate whether air injection is resulting in elevated total gas pressures, while the downstream values would indicate how gas levels respond to power station operation.

If oxygen supersaturation does occur under Basslink, then a program of more extensive monitoring of gas saturation levels should be developed and implemented.

3.3 Environmental Assessment of Land Impacts – Fluvial Geomorphology

3.3.1 Background

Results of investigations of the fluvial geomorphology of the Middle Gordon River by Koehnken, Locher and Rutherfurd are presented in full in Appendix 4 and summarised in this section.

Methods reflected the five main tasks identified for successful completion of the investigations:

- Examination of past and potential hydrologic changes: hydrologic modelling and monitoring
- Field inspection to look for evidence of erosion processes: mapping of bank features and properties, mapping of cobble bars, photo monitoring, tributary assessment, field consultation with relevant experts and other Basslink investigators
- Estimation of post-dam channel change: aerial photo comparisons
- Measurement of present hydrological and erosion processes: erosion pins, scour chains, painted cobble, largest cobble measurement, suspended sediment sampling, surveyed cross-sections
- Measurement of field properties of bank materials: sediment collection and particle size analysis, pressure transducers in banks to measure water levels, penetrometer measurements, bank stability modelling

Background information on geomorphology and soils for the Middle Gordon River is limited to that contained in the Lower Gordon River Scientific Study (LGRSS) in the mid-1970s (Roberts & Naqvi 1978; Christian & Sharp-Paul 1979). This report delineated the Middle Gordon River into a number of geomorphic land systems based largely on geological boundaries. In general, the east-west trending section of the Gordon River from downstream of the power station to the Orange River is comprised of repeated high dissected ridges and valleys underlain by competent Precambrian units.

Downstream of the Orange River to the Olga River, the Gordon River trends northwest and west through zones of younger limestone and sediment, before entering the low lying alluvial plain at the Olga River which is associated with the Gordon Limestone (see references to rivers in Map 3.2).

The most common sediments along riverbanks was a stratified alluvium, behind which is an almost universal occurrence of dark reddish-brown acidic fibrous peat, 20-50 cm thick, grading into shallow to deep siliceous sands. The soils were observed to be well-drained both externally and internally.

More recent geomorphic investigations (Nanson *et al.*1995) in the Stanley River in western Tasmania have documented strong river channel stability since the Pleistocene as a result of the re-establishment of dense riparian rainforest, and the longevity of fallen trees in the channel which reduce stream power and boundary shear stress. The researchers suggest this trend is applicable to the river channels and floodplains of Western Tasmania, and would suggest that the Middle Gordon River and its tributaries have very low natural erosion and channel migration rates.

The available background information provided some understanding of the gross geomorphic characteristics and influences on the Middle Gordon River, but was unable to provide a picture of the geomorphic response of the river system to 30 years of power station operation. Understanding of the processes, directions and rates of geomorphic response to historical regulated flow regimes was considered essential to this study as a baseline for assessing Basslink changes. A key question was whether the existing system was in geomorphic equilibrium with the regulated flow regime or still adjusting.

The damming of the Gordon River has altered all components of the flow regime that would be expected to significantly alter the fluvial geomorphic processes operating in the river (magnitude, duration, frequency, timing and rate of change of flows). The present Gordon River flow regime increases median flow conditions, decreases the frequency of high flow events, increases the duration of high river stage, reverses the seasonality and increases the flow rate of change compared to the pre-dam flow regime. From a review of the literature for other rivers, some preliminary predictions were made as to the potential response of the Gordon River to flow regulation.. The predicted responses include: minimal change to the bedrock channel reaches; minimal change to the gravel bed of the river due to armouring; deposition of tributary bars; and channel widening where bank material permits due to scour of the bank toe, increased duration of shear stress on the bank face, and accelerated drawdown rates. A decrease in meander migration rates might also be expected based on the literature, however given the extreme stability of the river channels in Southwestern Tasmania, it is unlikely to be detectable in the time frames examined for these investigations (decades). These predicted responses were targeted for the geomorphic investigations in the Middle Gordon River.

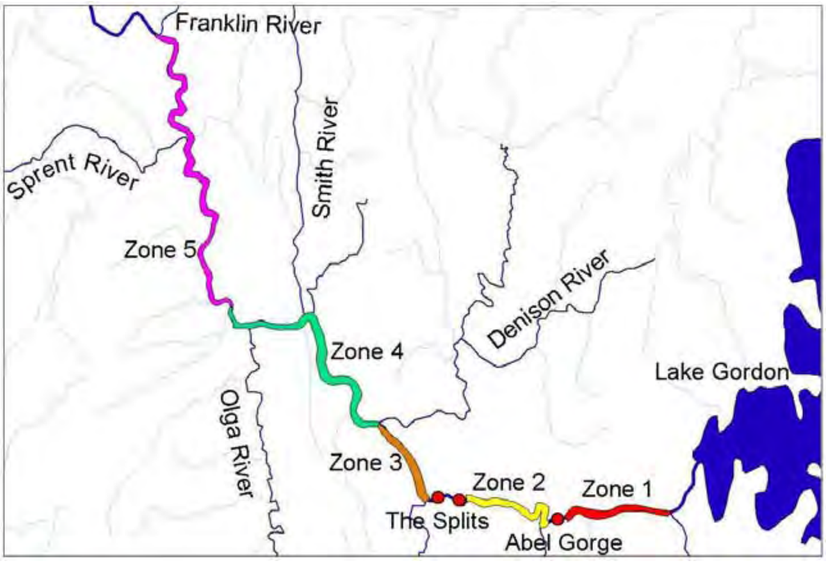
3.3.2 Field Investigations

Field investigations for this study were conducted between the period of October 1999 and October 2000, involving eleven separate visits to the river for direct geomorphological investigations and many more for data acquisition and field equipment maintenance. Hydrologically, the study year can roughly be divided into four parts. During the first part, October 1999 to December 1999, the power station was operated in a typical manner, with infrequent use of three generators and monthly average flows similar to long term averages. This provided an opportunity to observe the river under 'typical' flow conditions. Between January and April 2000, the station was operated at the highest monthly flow rate in the history of the power scheme, which allowed direct observation of very long-duration high flow events. Although this flow regime is very different from the anticipated Basslink flows, the response of the river to prolonged high flows provided very useful insights about processes and rates operating in the river.

During July, August and September 2000, power station operation again returned to more typical patterns, which allowed the testing of hypothesises developed during the first nine months of the investigations. The final observations and investigations were completed during an extended power station shutdown, during which time the tributary inputs dominated river flow. This allowed the investigators to directly observe 'natural' processes normally masked by the present flow regime, providing additional information about the effects of regulation on the Gordon.

For the purposes of the present study, the Middle Gordon River was divided into five geomorphic zones, based on the previously recognised geomorphological units from the LGRSS but refined for the requirements of the present investigation. The zones (shown in Map 3.5) were primarily delineated based on hydrologic controls (features that cause water to 'back up' such as major tributaries or gorges), with successive zones downstream reflecting the diminishing influence of the power station.

Monitoring sites were selected in each zone, and erosion pins, scour chains and piezometers were installed. Erosion pins provide a benchmark of riverbank surface to assess net erosion or net deposition between the periods of measurement. Scour chains provide an indication of the maximum scour that occurred during the period between the erosion pin measurements. This provides a more detailed history of erosion and deposition on the bank, because if scour is accompanied by deposition, erosion pins show little net change. Piezometers were placed at three locations in the Middle Gordon River to determine groundwater changes in the near river sediment banks in response to changes in river level.



Map 3.5 Downstream Gordon River geomorphic zones with major gorges marked by red dots.

Additional field data collection and subsequent analyses included:

- Collection of 95 sediment samples from throughout the Middle Gordon River. These were analysed for particle size distributions, and calculations made on hydraulic conductivities of the sediments to assess risks of seepage-induced erosion. The mineralogy of twelve of these samples was determined using X-ray diffraction.
- Painted rock experiments were undertaken to determine the dimensions of material able to be moved by the river as bedload at various distances downstream of the power station under present power station operations.
- Penetrometer readings at a number of points in the Middle Gordon River provided an indication of the cohesion and strength of the bank.
- Water samples were collected under conditions of power station on and power station off for analysis of total suspended solids.
- Detailed mapping with a hand-held GPS was undertaken of riverbank attributes relevant to this study for all accessible reaches of the Middle Gordon River (38 km). This mapping exercise only excluded the reaches immediately below the tailrace, Abel Gorge, the Splits and Snake Rapids, all of which are bedrock and so not prone to change due to power station operations. Key attributes were noted on a reach-by-reach basis and included bank material, height of water level changes, bank slope, bank surface characteristics, percent of tea-tree cover on the bank, percent of buttressing with logs or rock, percent of large woody debris, and level of recent erosional or depositional activity. Locations of point features of significance (e.g. landslips, bedrock promontories) were identified and recorded. All data was incorporated into Arcview-generated maps of the Middle Gordon River.
- Photographic monitoring of identified areas of recent erosion activity was tied in with the riverbank mapping exercise.
- Investigation of erosional characteristics of the Franklin and Denison Rivers as natural analogues of the Gordon River prior to flow regulation.

Field data was used as input data to SlopeW, a computer program which analyses slope stability, to compare the relative stability of sediment banks of different geometries and locations in the Middle Gordon River.

3.3.3 Present Geomorphic Condition of the Middle Gordon River

3.3.3.1 General Observations

The results of these investigations showed that the first two zones of the Middle Gordon River (from the power station to upstream of the Splits) have shown a significant yet predictable geomorphic response to the Gordon Power Scheme, and cannot be considered in equilibrium. Downstream of the Splits in Zones 4 and 5, the banks and bed show a moderate response to power station operations which diminishes with distance downstream. Zone 3 shows signs of both the upstream and downstream zones, so does not neatly fall into a group with either Zones 1 and 2, or Zones 3 and 4 (refer to Map 3.5 for zone locations).

Bank materials are either bedrock, cobbles, sandy alluvium, or a combination of these. By far the most significant geomorphic response is observed in the alluvial banks. Comparisons of 1974 with 1999 aerial photos show that overall the planform of the Middle Gordon River has not altered significantly in this time, and the only notable difference is in significant channel widening in the Albert River just upstream of the confluence with the Gordon River.

3.3.3.2 Zone 1

Zone 1 is a 5 km reach with 52% of the banks consisting of bedrock, and only 11% of fine alluvial material which is most prone to geomorphic adjustment due to power station operations. The hydrology of this zone is dominated by power station discharges, with less than 1.5% of the average annual total flow derived from natural pickup. The zone displays a very prominent and well-defined Plimsoll[1] line, below which there is no green vegetation. The Plimsoll line fluctuates between 1- 4 m above low water (power station off), depending on the occurrence of hydraulic controls such as Abel Gorge (which cause the greatest water level changes). Comparisons of aerial photos (1974 and 1999) show an actual narrowing of the river channel (as defined by the vegetation drip line) in a number of spots by as much as 15 m, reflecting that the reduction in high (flood) flows due to power station regulation has permitted growth of small rainforest species in a previously uncolonised zone of the banks. No channel widening or other channel adjustment was shown in the aerial photo comparisons except minor channel widening at the entrance to Abel Gorge. Alluvial banks which have little tea-tree cover show erosion processes actively occurring, including undercutting; scour, particularly of the lower bank; development of slots and voids at high water level causing localised “sediment flows” which form transient fan deposits on the lower banks; and landslips. Treefall is common where large voids have been created in the banks. Several recent landslips are documented in this zone, and are most commonly in cobble-containing bank materials occurring in very steep and high slopes. Cobble bars in the bed are largely immobile and armoured One new bar has been deposited since creation of the power scheme. The bar is situated in the first large ‘pool’ section of Zone 1, downstream of a long, steep bedrock reach. The bar is composed of mobile sands and gravels overlying larger, more angular clasts.

3.3.3.3 Zone 2

Zone 2 is a 2.5 km reach largely underlain by dolomite rock (refer to Appendix 5, the Gordon River Karst Assessment), and the riverbanks are composed of fine-alluvial material along 76% of this reach. The high percentage of alluvial banks and proximity to the power station make this zone most susceptible to adjustments due to flow regulation. As with Zone 1, there is a prominent Plimsoll line which varies between 1.5-3 m above the low water mark, with no vegetation present on the bank toes. Flow in this zone is also largely dominated by power station discharges, with natural inflows contributing approximately 6% of the total yearly flow. Aerial photo comparisons of the 1974 and 1999 photos show small scale retreat of the drip line in pockets by as much as 10 m, as well as

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[1] The Plimsoll line is a high water mark on the riverbank.

incursion of vegetation by up to 15 m in other small pockets. Bank mapping of this zone documented frequent and highly active erosional processes particularly on the alluvial banks with little tea-tree cover. Erosional features were concentrated along the high water level of the bank (river height corresponding to 3 generator operation). Erosional processes were similar to those identified in Zone 1 but more frequent and active, occurring along river reaches of tens of metres in length. Scour of the bank toes of up to 20 cm/yr was documented by erosion pin measurements.

Zone 2 banks display a higher proportion of fine sand and silt-sized material than Zone 1, which may account for the well-developed slots, voids and mass sediment flows out of the banks. Cobble banks show evidence of recent slip failures. Aerial photo comparisons show that there was considerable treefall in this zone in 1974, and those same fallen trees are still evident on the 1999 photos, supplemented by additional fallen trees. Cobble bars in the bed are largely immobile and armoured, with varying amounts of cementation on the surface. On some bars, the cementation has been breached either along the flanks or on the surface due to channel formation on the bar surface. Active ‘head cuts’ were observed at the downstream end of a few bars.

3.3.3.4 The Albert River

The Albert River shows clear evidence of tributary rejuvenation, with highly active erosion in the 500 m above the Gordon River confluence, and channel widening documented from the aerial photo comparisons of as much 30 m. The greatest adjustment is within 100 m of the Gordon River confluence. The bed of the Albert River shows a heterogeneous mix of highly mobile material, generally gravels and cobbles. The mechanism causing the widening of the Albert River mouth is believed to be the decoupling of flow regimes between the Albert River and the regulated Gordon River. Post-dam, the water surface slope at the mouth of the Albert River during times of flood is much steeper than it would have been under natural conditions when the Gordon River was simultaneously in flood.

3.3.3.5 The Splits and Snake Rapids

The Splits and Snake Rapids divide Zones 2 and 3, and are characterised by 2 km of bedrock controlled river channel over which the elevation of the river bed drops 20 m. These gorges, being bedrock, exhibit no geomorphic adjustments to power station operation other than a defined Plimsoll line with no vegetation present below the high water mark (similar to bedrock in Zones 1 and 2). Similar to the gorge areas in Zone 1, there has generally been an increase in vegetation in this area owing to the reduction of very high flow events under the present flow regime.

3.3.3.6 Zone 3

Zone 3 is a 3.5 km reach between the downstream end of Snake Rapids and the Denison River confluence, consisting of approximately half alluvial and half bedrock banks. Flows here are augmented by the Orange River tributary, increasing the natural inflows to this reach to 10% of the total yearly flow, almost a 2-fold increase over Zone 2. The reach is largely bedrock controlled, with overlying cobbles and alluvium present in the riverbanks in a highly dissected pattern. Similar erosional features seen in the upstream zones are also present in Zone 3 (piping, sediment flows, undercutting, scour), but occur on a smaller scale and as discrete occurrences. The river widens below Snake Rapids, resulting in smaller water level fluctuations, and hence a reduced proportion of the bank is devegetated and subject to scour. Aerial photo comparisons show pockets of increased treefall, notably at the mouths of the Orange and Denison Rivers, and some changes to vegetation on the instream islands. Cobble bars are less common in the zone, the bars are armoured, but not strongly imbricated or cemented.

3.3.3.7 Zone 4

Zone 4 is a 5 km long reach between the Denison River confluence and the top of Sunshine Gorge. The Denison River is a major tributary of the Gordon River, and significantly increases the natural inflows to the river to 30% of the total yearly flow, a three-fold increase over Zone 3. This major hydrological change to the Gordon River results in a more diffuse Plimsoll line in Zone 4. The Plimsoll line generally varies between 1-2 m in height, and fluctuates frequently due to a large number of bedrock controls. 31% of Zone 4 is fine alluvium, and 67% is either bedrock or alluvial materials overlying bedrock. Cobbles and bedrock are often present at the base of alluvial banks where they provide a buttress to stabilise the banks. Evidence of undercutting, piping, and seepage erosion is observed in the alluvial banks not colonised by tea-tree, but these features are on a smaller scale and distributed more widely over the bank. Some scour of the bank toes was evident from the erosion pin monitoring, but net changes were less than 10 mm overall during the year of monitoring. Tree falls are less common. There is a marked increase in the deposition of sands on the inside of river bends and in local backwater areas. Recent cobble landslips are not common. This is the first zone where recruitment of vegetation below the high water mark was observed. Aerial photo comparisons show only minor and localised changes. Cobble bars in the bed still tend to be armoured and slightly imbricated, but cementation is largely absent.

3.3.3.8 Zone 5

Zone 5 is the longest of the geomorphic study reaches and the furthest from the power station. It extends from below Sunshine Gorge for 12 km to the Franklin River confluence. The slope of the river over this zone is very shallow, dropping only a few metres over the full distance. The Olga River enters at the top of the zone, and the Sprent River also enters approximately 5 km upstream of the Franklin River confluence. These rivers increase the natural inflows to the river to about 40% of the total yearly flow, and as a consequence the Plimsoll line is even more diffuse than in Zone 4. Zone 5 is unique in that it is almost completely underlain by the Gordon Limestone, and bedrock with or without alluvium comprises 67% of the riverbanks. Zone 5 also differs from the upstream reaches in that vegetation is present below the high water mark, with the lower banks supporting mosses and ferns in limited areas, although a Plimsoll line is still evident. Depositional areas contain muds as well as sands. Alluvial banks contain many of the same erosional features identified for the upstream reaches, but are more limited in extent and distributed over a wider range of the bank. Very minor scour of the bank toes was indicated from the erosion pin monitoring, but deposition was also documented on the upper portions of the banks. Aerial photo comparisons show only minor and localised changes, including both loss and gain of vegetation. Cobble bars are less common, but some show a narrowing of the lateral lobes and some loss or gain of vegetation.

3.3.3.9 Comparisons with Unregulated Tributary Rivers

The Franklin and Denison Rivers, large tributaries of the Gordon that are similar geologically and hydrologically to the Gordon River, were investigated as natural analogues of the Gordon River prior to flow regulation. The occurrence of multi-generational slow growing huon pines stacked on top of each other on the banks of the tributaries suggests that these rivers, like the Stanley River (Section 3.3.1), have had very stable river channels for thousands of years.

Notable differences between the tributaries and the Middle Gordon River are that the unregulated rivers have noticeably more vegetation and organic matter down to low water level. This includes occurrences of mosses and ferns, as well as general leaf litter and organic debris. The deposition of very fine sands and muds is also more common in the tributaries. The tributary rivers display large amounts of treefall and large woody debris on the banks. Levels of treefall in most of Zones 3, 4 and 5 of the Middle Gordon River appear consistent with that observed in the unregulated rivers.

The same erosional features observed in the Middle Gordon River (undercutting, scour, seepage erosion/sediment flows, tree fall) were also observed in the unregulated rivers, although distributed over ranges of several metres on the banks corresponding to a range of high water levels. The density and size of these erosional features appeared to be lower and smaller in the unregulated rivers, although zones of extensive disturbance were present (e.g. the confluence of the Denison and Maxwell Rivers, and a major treefall in the Franklin River).

3.3.3.10 Summary of Present Condition

The following summary points can be made on the present geomorphic condition of the Middle Gordon River, based on the field observations and comparative aerial photo analysis.

- Bank materials exert a primary control on bank morphology in the Middle Gordon River, with alluvial banks more susceptible to modification than the bedrock or cobble banks.
- Bank toes and lower bank faces are devoid of vegetation in the upstream zones of the Middle Gordon River. In the lower Zones 4 and 5, there is a gradual reappearance of vegetation on the bank faces. This is in stark contrast with unregulated tributaries where the vast majority of entire bank faces are vegetated to low water level.
- Alluvial banks in the Middle Gordon River have been modified through scour and seepage erosion. Erosional features are concentrated and generally confined to the high water level of the regulated flow.
- Erosional features are more common, more extensive, and more ‘extreme’ in Gordon River Zones 1 and 2 where flow from the power station dominates total flow and water level fluctuations are greatest. There is a gradual decrease in occurrence and ‘intensity’ of erosional features in the Gordon River with distance downstream. A major decrease in number of erosion features occurs downstream of the confluence with the Denison River, where unregulated flow becomes a major component of total flow.
- Banks vegetated with tea tree, which have the ability to withstand extended periods of inundation, have generally not been affected by seepage erosion due to the stability provided by the root system, but scour of the roots is widespread.
- Tree fall is common on banks showing seepage erosion features, and is widespread in Zone 2.
- Vertical cobble banks are prone to slip failures that retain the vertical bank slope.

Overall, the geomorphic effects of flow regulation appear to decrease with increasing distance from the power station, as the proportion of regulated flow to total flow diminishes and water level fluctuations associated with power station operation decrease.

3.3.4 Present Geomorphic Processes and Rates

3.3.4.1 River Bed, Instream Cobble Bars and Bedrock Banks

The observations and experimental results from these investigations suggest that flow regulation has lead to the following changes to the river bed and cobble bars in the Middle Gordon River:

- The number and location of cobble bars in the study area has not altered between 1974 and 1999, with the exception of one new bar being deposited in Zone 1;
- Bar crests and surfaces above the present high water level are immobile, and have been colonised by vegetation;
- Bar surfaces that are inundated at high water are largely immobile, and characterised by algal coatings, cementation, armouring and imbrication;
- Some cobble bars in Zones 1 and 2 are being incised by the formation of channels, and head cutting is occurring at the downstream end of several bars;

- The flanks and submerged portion of bars are active, and have been modified between 1974 and 1999, with a narrowing of bars due to the loss of lateral lobes;
- The reduction in high flows due to flow regulation has greatly reduced the size of bed load transported under the present high flow conditions;
- The present bed load of the river is limited to predominantly sand, gravels, and small platy cobbles; and
- The discharge from the power station may be a factor in the supply of sand to the river, with higher water levels resulting in greater sand transport.

The extent of bedrock exposures along the banks of the Middle Gordon River is estimated to be 55%, with numerous gorges and rapids extending several kilometres. The typical appearance of bedrock riverbanks and mid-stream outcrops is clean, sometimes polished rock exposed up to the high water mark with sparse to dense vegetation present above this point. Changes in the rate of bedrock erosion through physical or chemical weathernig is unlikely to be related to flow regulation at a discernible scale. The aerial photo comparison has shown that there has been a loss of vegetation below high water level, and an increase in vegetation above the present Plimsoll line.

3.3.4.2 Fine Alluvial Banks

The primary erosional processes evident in the fine alluvial banks of the Middle Gordon River are scour and seepage erosion and are directly related to the regulated flow of the Gordon River. Erosional features are more common closer to the power station, and diminish in occurrence and extent downstream. This decreased occurrence coincides with an increase from tributary inputs, and a general decrease in the height of the power station controlled water level fluctuations.

The loss of vegetation below high water level through inundation and water logging has been a primary factor in the destabilisation and erosion of the banks, as vegetation has been found to be the major stabilising force in Western Tasmanian rivers. Scour and ‘notching’ of the banks at high water level has lead to undercutting of the coherent organosol, which frequently forms a ‘drape’ over the lower bank. Scour of bank toes occurs throughout the study area, and although the data is limited, appears to increase with higher power station discharge.

Prolonged saturation of the banks at high water level through long duration power station operation coupled with unnaturally high drawdown rates promote seepage erosion leading to additional undercutting of the banks. In general, seepage erosion is most prominent following the use of all three generators in the power station, with fewer seepage features present following power station operations involving 1 or 2 generators. This leads to the conclusion that the area of banks subjected to water level changes involving 1 or 2 generators are in at least quasi equilibrium with respect to seepage erosion, and is probably related to the dominant usage of 2 generators over the past 30 years. Simultaneous use of all three generators has only been possible since 1988 when the third generator was installed, and historically has occurred less than 10% of the time. Given this, it is not surprising that the higher bank areas inundated by three-generator use are still showing a marked response to inundation.

Stabilising bank processes include increased cohesion due to plant roots, protection of the bank face by the organosol ‘drape’ and buttressing by large woody debris (LWD), boulders and cobbles. LWD also reduces stream power and shear stress, thus locally reducing scour. Stabilisation of the bank toe and face through the deposition of LWD is recognised as a major stabilising process in unregulated southwest rivers and postulated to be the stable endpoint in geomorphology Zones 1-3 where impacts from the power station are most pronounced. This can be considered to be a long-term process, because the LWD is comprised of trees such as Huon Pine that resist decomposition on the time scale of thousands of years.

The alluvial banks presently showing the highest levels of erosional activity are those which have a steep slope, are subjected to large fluctuations in river level, do not support tea tree in the riparian zone, and are devoid of large woody debris or cobbles or bedrock at the toe of the bank. An assessment of the alluvial banks' susceptibility to erosion based on these criteria found that the potential for erosion in general decreases with distance from the power station. The greatest concentration of 'high' susceptibility to erosion areas is in Zone 2, with more limited areas identified in Zones 1 and 3.

The active erosion processes in Zone 1 and Zone 2 have resulted in channel widening in short reaches of the river since the initiation of power station operation. Natural rates of channel changes in Southwest Tasmania are largely unquantified, but are understood to be extremely low. Compared to this baseline, the post-dam channel change rates are very 'high' but the comparison is unquantifiable. Channel widening in the study area is not anticipated to result in planform changes to the river system beyond the localised widening of alluvial 'pockets' observed in aerial photo comparisons (1974 and 1999). These 'pockets' are less than 15 m in length and 10 m in retreat, and occupy an equivalent of ~10% of Zone 2 or 1% of the Middle Gordon River. The aerial photo comparisons are considered accurate to within 1-2 m, with the errors attributed to the channel margins being defined by vegetation driplines rather than a clear view of the water's edge (both sets of photos were flown at comparable periods of low flow). Bank profile adjustments which have occurred extensively in Zones 1 and 2 are not apparent from the aerial photo comparisons, as in most cases they do not change the location of the water's edge.

3.3.4.3 Cobble Banks

Cobble banks in the Middle Gordon River are more stable than the sandy-alluvial banks. This is supported by the weathered coatings and colonisation by mosses and lichens on the banks above high water level and the similarities in aerial photos between 1974 and 1999 for reaches dominated by cobbles. Buttressing and protection of the bank toe by cobbles derived from previous failures limits scour.

A number of cobble bank failures were observed during the summer of 2000, and are believed to be related to the unique high river flow experienced by the river during this period. It is theorised that prolonged inundation lead to atypical saturation of the banks, which upon drawdown resulted in slip failures.

3.3.5 Implications of Basslink

The key aspects of the Basslink hydrological changes, which have implications for riverbank stability in the Middle Gordon River, are the increase in the percentage of time of full capacity discharge, and the increased on-off fluctuations of the power station more fully utilising the range of flows.

Basslink is projected to result in changes to the geomorphic processes controlling stability of the Middle Gordon River banks by the following mechanisms:

- Scour of alluvial banks may increase, as high flows, and steep water surface slopes associated with the power station turning on, occur a greater proportion of the time.
- Vegetation losses are projected to be accelerated due to longer duration high flow at the three turbine operating level (see Section 3.5.2, Appendix 6).
- A change in patterns of riverbank saturation due to shorter periods of power station on will alter conditions leading to seepage-induced erosion. The probability of 'worst case conditions' which lead to full bank saturation are lessened with Basslink, because power station discharge durations are short and there are more opportunities for drainage of the banks with frequent power station shutdowns. However, the average annual number of drawdown events increases significantly with

Basslink, which may lead to an increase in the occurrence of seepage induced erosion, but probably not an increase in severity because banks are less saturated.

It is important to note what Basslink is not likely to change:

- There will be no significant broad scale changes to the planform of the river, as the river channel is largely controlled by bedrock.
- There will be little change to bedrock or vertical cobble riverbanks, except perhaps a minor upward adjustment of the Plimsoll line.
- Generally, the placement and morphology of instream cobble bars, which are largely stable under the present flow regime of the river, are unlikely to be affected by Basslink. In Zones 1 and 2, the incision and head cutting of bars is likely to increase due to increased high flow. Vegetation on bars below high water level will continue to be lost in Zones 1 – 3 due to scour, as is occurring under the present flow regime.
- The size of bed load material transported by the river will not change, especially in the reaches above the Splits where bed load input by tributaries is limited.
- Alluvial riverbanks will continue to show the greatest response to flow regulation.

3.3.6 Mitigation Options

Basslink will result in changes to the geomorphic processes controlling stability of the Middle Gordon River banks. These are an increase in the probability of scour, and an alteration to conditions leading to bank saturation thus modifying seepage erosion processes.

Mitigation options for geomorphological impacts of Basslink focus on reducing scour and seepage erosion. Identified mitigation options include a re-regulation dam, physical buttressing of the banks, reduction of the maximum power station discharge (to reduce zone of bank saturation), partial power station ramp-downs (to reduce phreatic surface gradient in banks), minimising the duration of three turbine discharge (to reduce extent of bank saturation), maintenance of a minimum environmental flow (to lessen scour of bank toe and reduce phreatic surface gradient), or a combination of these. An example of a potential power station operating rule which is receiving close consideration is the ‘210-150’ rule, which requires the power station to step down from discharges greater than 210 m^3/s to 150 m^3/s for one hour before shutting down, with the aim of allowing drainage of the upper portion of the bank and reducing draw-down rates. Additionally, any mitigation measure that would increase the viability of riverbank vegetation was viewed as being beneficial to the geomorphology of the study reach.

3.3.7 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- ➢ the monitoring considerations of the individual researchers;
- ➢ the Basslink-related options arising from those considerations; and
- ➢ studies suggested by the researchers which, while not directly measuring Basslink effects, may contribute to better understanding of the geomorphic processes in the Gordon River.

3.3.7.1 Researchers’ Monitoring Considerations

The monitoring suggestions made in Appendix 4 aimed to establish better baseline data and understanding of processes, establishing additional monitoring sites and determining the post-Basslink effects on the Gordon River geomorphology. They also stressed the importance of integrating the monitoring activity with those of other disciplines, but especially vegetation monitoring, and assessing the inter-annual variability under the present operating conditions.

Continued measurement of established erosion pins in stable or semi-stable areas was suggested in order to extend the available pre-Basslink dataset relating to scour of the bank toe, and to establish or confirm the relationship between power station operations and scour response. Some changes to methodology in highly erosive banks were also suggested.

The establishment of additional erosion pin and scour chain sites was suggested, although the precise number and location were not given.

It was suggested that robust, long-term piezometer sites be established, one upstream and one downstream of the Denison River confluence. A long-term goal with piezometer data from these sites would be a bank saturation-phreatic surface gradient model through which hydrological and rainfall time series data could be run, so that the implications of different scenarios on phreatic surface gradients could be assessed.

Regular photo monitoring of selected sites was suggested to provide information about rates of processes, ‘end points’ and the relative stability of different banks. As well, photo monitoring of cobble bars was suggested, in order to provide information about the stability of the bar surfaces and rates of undermining through cobble movement on the flanks.

The study further suggested that aerial photography of the Middle Gordon River, including the lower Albert River and the mouths of other tributaries, should be repeated at 5 to 10 year intervals. These photos would then be compared with earlier aerial photography to assess changes to channel width and vegetation.

3.3.7.2 Basslink-related Monitoring Options

The above monitoring activities should be undertaken both before and after the implementation of Basslink, in conjunction with other monitoring activity detailed in the Gordon Basslink Monitoring Program (see Section 3.10).

3.3.7.3 Suggested Studies

The Fluvial Geomorphology Assessment (Appendix 4) identified areas of geomorphic research which may be of interest to pursue further:

- Understanding the influence of rain on bank saturation (note that the study period was very dry);
- Identifying the precise hydraulic conditions leading to seepage induced sediment flows (this may at a future data lead to refinement of the recommended power station operational constraint);
- Understanding water movement through vertical cobble banks (local variability and logistical constraints may make this difficult, and photo monitoring may be sufficient); and
- Establishment of a sediment budget for the Gordon River (this will be difficult due to cost and logistical constraints).

3.4 Environmental Assessment of Groundwater Impacts – Karst Geomorphology

3.4.1 Karst in the Middle Gordon River

Potential impacts on karst in the Gordon River were investigated by Deakin, Butt and Desmarchelier, and the full report on their investigations is provided as Appendix 5.

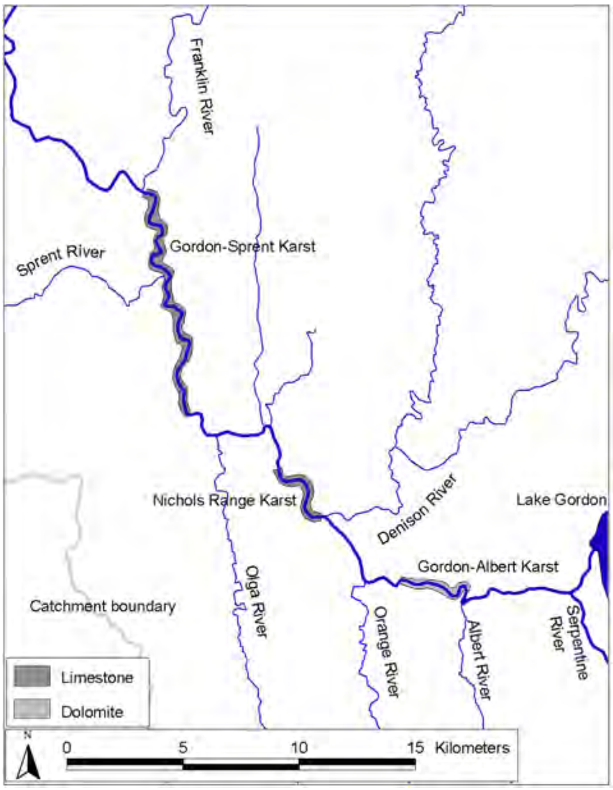
Karst is a distinctive landscape created by a high degree of rock dissolution, typically found in carbonate rocks such as limestone and dolomite. Within the Tasmanian Wilderness World Heritage Area, there have been significant karst systems identified, very notably the caves in the Franklin River which contain evidence of Aboriginal occupation.

In the Middle Gordon River, between the Gordon Dam and the Franklin River, karstic rocks outcrop along the Gordon River channel in three main areas shown on Map 3.6. Additionally, a dolomite outcrop has been identified between the Serpentine River and the Albert River. The three main karst areas are:

- The Gordon-Albert karst comprising a low lying area of dolomite rocks extending approximately 3 km along the Gordon River just downstream of the Albert River confluence. Most of the outcrop is located in the upstream kilometre of the stretch, in the vicinity of the major bend in the river. Karst features observed in the proximity of the river include a number of dolines, small springs, three stalactites, some well-developed solution features, and a small cave named by the karst team as Middle Landing Hole (too small to enter).

- The Nicholls Range karst comprising a low lying area of limestones extending approximately 3 km along the Gordon River just downstream of the Denison River confluence. Most of the outcrop is present in the downstream kilometre of the stretch. Karst features observed in the proximity of the river include two previously described caves connected to the river channel (Bill Neilson Cave and Kayak Kavern), karst springs, limestone cliffs, and solutional features such as notches, karren and scallops.

- The Gordon-Sprent karst comprising approximately 12 km of limestone rocks in the low lying area surrounding the Gordon River between the Limestone Creek confluence and Pyramid Island. Karst features observed in the proximity of the Gordon River include the previously known Rocky Sprent cave, a small number of other very small caves, some dolines, numerous solution features in the limestone rocks, evidence of scalloping and karren, and a well-known calcite formation on Angel Cliffs.



Map 3.6 Karst areas along the Gordon River

3.4.2 Methodology

Investigations aimed to identify and assess the significance of karst landforms, cave contents and geo-hydrological processes which may be affected by power station operations, and interactions between karst and fluvial processes which may influence river bank stability. The latter refers particularly to an assessment of whether or not karst drainage influences formation of sediment flows described in the geomorphology report (Appendix 4). Backwater channels are observed throughout the Middle Gordon River, and the karst team investigated whether or not these were a karst feature as well as commenting on their linkages to occurrence of sediment flows.

The research team reviewed reports of caving expeditions in the late 1970s which provided good baseline descriptions of karst features in the Nicholls Range and Gordon-Sprent karst areas. However there were no background data available for the Gordon-Albert dolomite karst, which was unknown prior to these Basslink investigations. Desktop analyses also encompassed aerial photo assessments from 1974 and 1999.

Field investigations were carried out for the three areas during July-September 2000, with the majority of field effort directed to investigation of the 500 m long Bill Neilson cave in the Nicholls Range karst, and the Gordon-Albert karst as it is closest to the power station and was previously unknown. Field investigations also included brief assessments of Kayak Kavern, a 25 m long cave just upstream of the Bill Neilson cave, and a limited assessment of the 35 m long Rocky Sprent cave just downstream of the Sprent River. Field data collected included mapping, cave and backwater channel surveying, water level recording, and water sampling.

3.4.3 Findings

3.4.3.1 Bill Neilson Cave

The Bill Neilson Cave is approximately 500 m in length and is the biggest known cave in the area. The entrance chamber is 8 m high by 5 m wide and the cave floor is just above the river water level with the power station off. The passageway is big enough to comfortably walk through to the end of the cave. There are several large daylight holes in the roof. A relatively large cave stream flows the full length of the passageway and there are several large sediment banks throughout. Calcite formations are present but are not common in the cave.

The level of inundation during normal power station operations and low rainfall conditions is approximately 0.76 m RL[2], which is 2.17 m above the cave floor at the entrance. Based on monitoring devices and evidence in the cave, the influence of the power station extends less than 180 m into the cave during low flow conditions. Higher older scum lines suggest that full gate discharge combined with high Denison and Albert River flows, and with high flows in the cave stream, can raise the water level up to 2.1 m RL, corresponding to a distance of 270 m back into the cave. Cavern stream flows are estimated to reach 0.4 m^3/s due to rainfall events.

Comparison with a pre-dam cave survey from 1976 shows that in the first 50–60 m of cave passage, the streamside was composed of river gravels whereas now the gravels are overlain by fine sediment banks. These fine sediment banks are quite thick (~30–40 cm) and there is evidence of layering parallel to the surface, suggesting that ongoing deposition may be occurring. Evidence of scour was observed at lower levels in the deposits, probably associated with the cave stream, and this could be maintaining a sediment balance. A large dry sediment bank extending into an upper level passage lies just above the estimated maximum Gordon River inundation level in the cave. Should the Gordon River maximum inundation level change significantly, destabilisation of these sediments may become an issue.

With the exception of the sediments, it is considered that the cave is relatively robust at the present time as all speleothems and glow-worm colonies are located high above the inundation level.

3.4.3.2 Kayak Kavern

Kayak Kavern is a major undercut in a carbonate cliff, which has been closed off to the front by a large block of limestone that has slipped into position. The cave is approximately 25 m long, and is floored by a large silt bank dipping steeply into the Gordon River. No speleothems were observed. All available evidence suggests that the Gordon River water inundates the cave on a regular basis under current power station operations, and that significant deposition onto the large sediment bank is occurring.

3.4.3.3 Rocky Sprent Cave

Rocky Sprent cave is a small (35 m) river level cave which opens out into a canyon and has a large daylight hole along its length. There are no significant features or speleothems present. A relatively high velocity stream flows through the canyon and into the cave, and this, with the narrow exit route to the river and the rapidly changing river water levels have ensured that the system is fairly robust.

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[2] For the purposes of the investigation, an arbitrary reference or datum point (0 m RL) was selected at the base of a protruding section of rock on the west wall of the cave close to the entrance. All inundation levels are measured as ±x m RL.

3.4.3.4 Other Caves

Several previously undescribed holes and a small cave were found on high ground between the Denison River and Bill Neilson cave at least 8–12 m above the low river level, and downstream of Angel Cliffs approximately 10–15 m above the low river level. Almost all were dry and as they were high above the zone of fluctuation of the river they not considered further. One small vertical cave in the Nicholls Range karst had water flowing in the bottom of it approximately 4–5 m from the surface but was too small to get into for further investigation. No decoration was evident from the entrance.

3.4.3.5 Interactions between Karst and Fluvial Processes Influencing Bank Stability

The karst team investigated the potential interactions between karst and fluvial processes affecting river bank stability. The team concluded from limited investigations that backwater channels on the Middle Gordon River are a surface runoff feature which are not necessary for the development of sediment flows. They do not appear to be specific to karst areas or dependent on karst groundwater for their development. The sediment flows are also considered to be independent of karst groundwater. These features are further discussed in Appendix 4 (Gordon River Fluvial Geomorphology Assessment).

3.4.4 Management Issues

The main karst features which appear susceptible to impact from power station operations are the cave sediment deposits in the entrances to Bill Neilson cave and Kayak Kavern. Under Basslink, the banks may experience more active deposition due to deposition of fine sediments with more frequent inundation. At the same time, the banks may experience active slumping and collapse from recurrent saturation and dewatering under a Basslink flow regime in the Gordon River.

Cave sediments can potentially provide valuable information about past environmental conditions. However, the sediment deposits described at the entrances to the Bill Neilson cave and Kayak Kavern are considered by the researchers to be relatively recent, probably post-power station development. The researchers concluded that these sediment deposits are not significant and do not merit any special management or mitigation considerations.

The dry sediment bank which is currently located beyond the estimated extent of inundation could be destabilised in the future should there be any change in the maximum inundation level of the Gordon River during the winter months, due to the higher probability of flood events occurring concurrently with full gate power station operations.

3.4.5 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- the monitoring considerations of the individual researchers;
- the Basslink-related options arising from those considerations; and
- studies suggested by the researchers which, while not directly measuring Basslink effects, may contribute to better understanding of the processes in the karst areas of the Gordon River.

3.4.5.1 Researchers’ Monitoring Considerations

The researchers suggested (Appendix 5) a program of pre- and post-Basslink monitoring, including:

- ➢ sediment movement in both the Bill Neilson cave and Kayak Kavern, using the existing erosion pin installed in each cave, in conjunction with additional pins to be installed by a sedimentologist or geomorphologist;
- ➢ water levels in Bill Neilson cave; and
- ➢ sediment transfer in dolines close to the river bank in the Gordon–Albert area, using erosion pins.

3.4.5.2 Basslink-related Monitoring Options

Of the above suggestions, only the sediment movement is expected to be directly affected by Basslink operations, and this is not considered to be a major karst issue due to the recent nature of the sediment deposition. The water levels in Bill Neilson cave would become an issue if high catchment water levels combine with high discharge levels to inundate normally dry parts of the cave. The likelihood of such combined high water levels occurring is presently unknown. Nevertheless, some monitoring of the two caves would be prudent to ensure that the trends and processes remain within the bounds predicted.

Consequently, work which should be included in the Gordon Basslink Monitoring Program (Section 3.10) includes the continued monitoring of erosion pins (both current and new installations) in Bill Neilson cave and Kayak Kavern, and continued monitoring of water levels in the Bill Neilson cave in response to rainfall and power station operations. Monitoring of newly installed erosion pins in the Gordon–Albert karst area should also be conducted. Regular visual checks of dolines, accompanied by erosion pins installed as reference points and photo monitoring, will also be incorporated into the Gordon Basslink Monitoring Program.

This monitoring can be readily integrated with the geomorphic and cave biota monitoring activities.

3.5 Environmental Assessment of Flora and Fauna Impacts

3.5.1 Scope of this Section

This section looks at environmental information on the Gordon River flora and fauna in relation to present status and potential Basslink changes. Specific aspects of the flora and fauna which are examined are the riparian vegetation (Section 3.5.2), macroinvertebrates (Section 3.5.3), fish (Section 3.5.4), platypus and native water rats (Section 3.5.5), terrestrial fauna (Section 3.5.6) and cave flora and fauna (Section 3.5.7).

3.5.2 Riparian Vegetation

Riparian vegetation in the Gordon River downstream of the power station was assessed by Davidson and Gibbons, with their full report provided as Appendix 6.

3.5.2.1 Methodology

The methodology employed by the researchers involved the following:

- Review of hydrological information;
- Mapping of Gordon River riparian plant communities (from Abel Gorge to the Splits);

- Surveys of cover and abundance of plant species in the Gordon River, and the unregulated Denison River and Franklin River tributaries;
- Assessments of recruitment within each survey quadrant;
- Sampling and analysis of root mat densities at two types of sandbanks; and
- Assessment of the contributions of mosses to stream bank stability.

The surveys of cover and abundance compared two river sections in the Gordon River (Abel Gorge to First Split, Second Split to Ewarts Gorge) with a reach of the Franklin River and a reach of the Denison River. Transects of contiguous 2x2 m quadrats were made so that two replicate transects were obtained on each of five common substrates: rock bar, cobble bank, sand bank, mud bank and steep riverbank overhung by rainforest. Species were grouped into seven vegetation guilds: trees, tall shrubs, low shrubs, herbs, grass, graminoids and ferns. Detailed statistical analyses were conducted on the data.

3.5.2.2 Present Status

In the unregulated tributary rivers assessed in this study (Franklin and Denison), the riparian vegetation extends from the low summer river flow level to the peak flood level, where it grades into the adjacent rainforest species. A decline in species richness in the riparian zone of the Gordon River downstream of the power station, as compared with the Franklin and Denison rivers, is clearly documented by the researchers.

The Gordon River riparian vegetation between Abel Gorge and the Second Split shows a very distinct vertical zonation, as follows (note that the exact bank heights will vary depending on the local morphological and hydraulic characteristics):

- Between approximately the low water mark (LWM) and 1.5 m above this (corresponding to 1 generator discharge from the power station, ~70 m^3/s), the riverbank is mostly bare mineral substrate. In some cases there are opportunistic semi-aquatic species present.
- Between approximately 1.5 and 2.5 m above the LWM, the cover and diversity of riparian species is much reduced within most vegetation guilds, but there is an increase in the contribution from grasses. 2.5 m corresponds to 2 generator discharge from the power station, ~140 m^3/s.
- At approximately 2.5 m or not far above this is the ‘Plimsoll’ line (used here to refer to height of power station impact, shown by a line in the trees or shrubs below which there are no green leaves), corresponding to two generator or between 2-3 generator discharge from the power station.
- Between approximately 2.5 and 4 m above the LWM, the banks are only inundated when the third generator is operating. Efficient load operation of all three generators discharges 210 m^3/s, which equates to approximately 4 m above the LWM; this height has only been reached 9% of the time over the past 10 years (based on information in Table 3.1). In this zone there is a decreased fern and tree cover compared with the tributary streams, but increased tall shrub cover.

The heights of 1.5, 2.5 and 4 m are used as indicative heights above the LWM, but vary depending on the local hydraulics of the particular site in the river. For example, the water level above the LWM when the power station is discharging at full capacity can vary by as much as 2 m between sites within a gorge versus a more open part of the river.

The bank zonations defined above decrease with distance down the Gordon River below the Splits, as well as with increased channel widths.

Important mechanisms which stress the riparian vegetation in the Middle Gordon River are inundation, waterlogging, and light limitation:

- Inundation is the submergence of vegetation, that prevents gas exchange and prevents plants carrying out photosynthesis and respiration through their leaves;
- Waterlogging is the submergence of the root zone, which causes depletion of oxygen in the soil and prevents respiration by plant roots; and
- Light limitation is a stress because plants require adequate daylight hours without inundation or waterlogging to acquire carbon through photosynthesis. This occurs when the power station is on during the day but off at night, and on during summer and off in winter.

In general, the cover of mosses, herbs and low shrubs is greatly reduced in the zone 0-1.5 m on the river bank between Abel Gorge and Ewarts Gorge. This reduction is caused by water logging or inundation and light limitation. Many terrestrial and epiphytic mosses which appear to play a key role in bank stability in the unregulated rivers are notably missing from the Middle Gordon River.

Leptospermum riparium (tea tree) is the tall shrub species most resistant to waterlogging, and in many cases is the only shrub species representing the riparian community, 0-1.5 m on the bank of the Gordon River upstream of the Second Split. It often shows poor health indicated by thinning crowns, dead lower limbs and exposed roots due to sand scour. There is little or no recruitment.

Other effects on the riparian vegetation relate to landslips and bank collapse as described in Section 3.3 and Appendix 4. Landslips carry with them masses of attached vegetation, as well as mature rainforest established above the riparian vegetation.

The islands which hold a significant proportion of the diversity of riparian vegetation in the Gordon River are showing losses of many riparian species up to the Plimsoll line. These islands are exposed to erosional processes similar to the river banks, and the long-term prognosis for the island vegetation is poor.

Recruitment is severely limited in the Gordon River riparian vegetation. Between the power station and Ewarts Gorge, only six sites were observed with recruitment of seedlings. Most of these were in unique situations enabling survival of the seedlings. Two of the sites were well down the river, and it was as far downstream as Ewarts Gorge before evidence was seen of recruitment by a combination of riparian shrubs and herbs common in the Denison and Franklin Rivers. The poor health and lack of recruitment mean that under existing operations of the power station, even the tea tree are likely to disappear from the riparian zone in the future.

The riparian vegetation in the Gordon River downstream of the Power Station to the Denison River is heading towards a state at which the banks and islands consist of mineral substrates and log debris, with a sharp transition into rainforest. The exception to this may be some hardy mosses highly tolerant of inundation.

3.5.2.3 Potential Basslink Changes

Basslink is expected to cause further changes in the riparian vegetation of the Middle Gordon River, with the main mechanisms being:

- Increased frequency of inundation and waterlogging in upper portions of the river bank (note that this is due to the projected Basslink increase in discharge using all three generators, which is believed to be an over-estimate); and
- A shift in flow patterns towards operation at maximum discharge during the day and minimum discharge at night.

Inundation would occur up to 4m on the river banks more frequently than under existing operations. Water logging would also occur to up to 4m on the river banks more frequently than under existing operations, but the intensity of waterlogging would be reduced through more frequent drainage of the banks. Basslink would operate more consistently during daylight hours reducing the exposure to light required by the plants for photosynthesis.

The main impact is expected to be a slight shift in the existing vertical zonation of riparian vegetation observed between Abel Gorge and the Splits. This would see the bare mineral substrate between LWM and 1.5 m broaden up to 2.5 m, and between 2.5 and 4 m to experience reduced total species cover and increase in cover with grasses tolerant of submersion. Greater than 4 m may experience an increase in tall shrub cover relative to the tributary streams.

More frequent peak flows are anticipated to cause a number of geomorphic effects with regard to localised scour, erosion and landslips (Section 3.3 and Appendix 4) with consequent localised effects on the riparian vegetation.

More frequent peak flows are anticipated to accelerate the rates of loss of tea tree stabilising the banks of the Middle Gordon River. Recruitment would continue to be inhibited.

These effects are anticipated to be greatest upstream of the Splits, and decrease with distance downstream from the Splits. Effects including the presence of a Plimsoll line, below which there is a reduction in the cover and diversity of riparian species, would be experienced as far downstream as the Franklin River.

3.5.2.4 Mitigation Options

Mitigation measures presented in Appendix 6 which could be considered to enhance the condition of the riparian vegetation include:

- Instigating low flow rates (<50 m^3/s) for three summer months (January to March) every year to allow riparian plants to grow and reproduce and for recruitment to occur during the season of greatest metabolic activity. In addition instigate 24-48 hour shutdowns on most weekends for the remainder of the year to reduce stresses of waterlogging and inundation. Because of the lack of propagules it would also be necessary to facilitate regeneration by direct-seeding of the river banks with local riparian species. Note that these are not specifically Basslink mitigation options (that is, options that specifically mitigate against changes to the current conditions arising from the Basslink changes to Gordon Power Station operations), but rather ones that address the existing effects of power station operations which would continue under Basslink.

  Expected effect: Optimally, some recovery of vegetation affected by the present regime and new recruits at heights 1.0-2.5 m on the bank in the region between the dam and Ewarts Gorge and to a lesser extent beyond this to the Franklin River; however, this may all be wiped out when normal power station operatons resume.

- Reduce maximum discharges (e.g. to a maximum flow of 210 m^3/s) so the power station operation under Basslink does not reach so high on the bank.

  Expected effect: Riparian vegetation would be affected to a height of 3.5 m on the bank rather than 4.0 m in the zone upstream of the Splits.

- Minimise the duration of maximum discharges under Basslink.

  Expected effect: Reduction in the rates of vegetation loss at height close to the HWM on the riverbanks upstream of the Splits.

- Implement options to minimise bank erosion.

Expected effect: Reduction in loss of vegetation through undermining and landslip, and greater opportunity to revegetate bare mineral substrates.

3.5.2.5 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- the monitoring considerations of the individual researchers;
- the Basslink-related options arising from those considerations; and
- studies suggested by the researchers which, while not directly measuring Basslink effects, may contribute to better understanding of the riparian vegetation processes of the Gordon River.

3.5.2.5.1 Researchers’ Monitoring Considerations

The principal monitoring suggestion from this report (Appendix 6) was to conduct a study of the riparian vegetation before and after Basslink is implemented, allowing the effects of this operational change to be better quantified. The report indicated that the present study could be considered an adequate 'before' study. Post-Basslink monitoring would need to include some continuation of this ‘before’ study, but may also include comparison with unregulated tributary rivers.

3.5.2.5.2 Basslink-related Monitoring Options

Consequently, the Gordon Basslink Monitoring Program (Section 3.10) will include a component of replicate riparian vegetation studies commencing post-Basslink and being repeated at two to five years after that.

3.5.2.5.3 Suggested Studies

The report (Appendix 6) identified areas of research which would benefit from further study:

- Measuring dissolved oxygen concentrations in riverbanks to assess severity of waterlogging;
- Assessing the role of mosses in the riparian communities. The presence of mosses on the riverbank appears to be a key indicator of disturbance by inundation;
- Assessing the relative importance of inundation, waterlogging and light limitation at different height zones in the river banks;
- Assessing rates of change in vegetation species cover and diversity on the central islands;
- Assessing the effects of the major tributaries in reducing the severity of impacts with distance downstream from the dam;
- Assessing the levels of natural recruitment of riparian species on river banks in the middle and Lower Gordon River; and
- Assessing the effects of the flow regime on reproduction and seed set of riparian species.

3.5.3 Aquatic Macroinvertebrates

The assessment of macroinvertebrates was conducted by Freshwater Systems and is reported in full in Appendix 7.

3.5.3.1 Method

The macro-invertebrate assessment had little baseline information upon which to draw. No faunal surveys were conducted in the Gordon River prior to the Gordon Power Station development. The only previous studies are macroinvertebrate surveys conducted in 1977 and 1978 by Coleman (1978) for the Lower Gordon River Scientific Survey Report, and sampling by Davies *et al.* (1999) as part of a comparative state-wide assessment of changes in aquatic biota and instream habitat downstream of hydro-electric infrastructure.

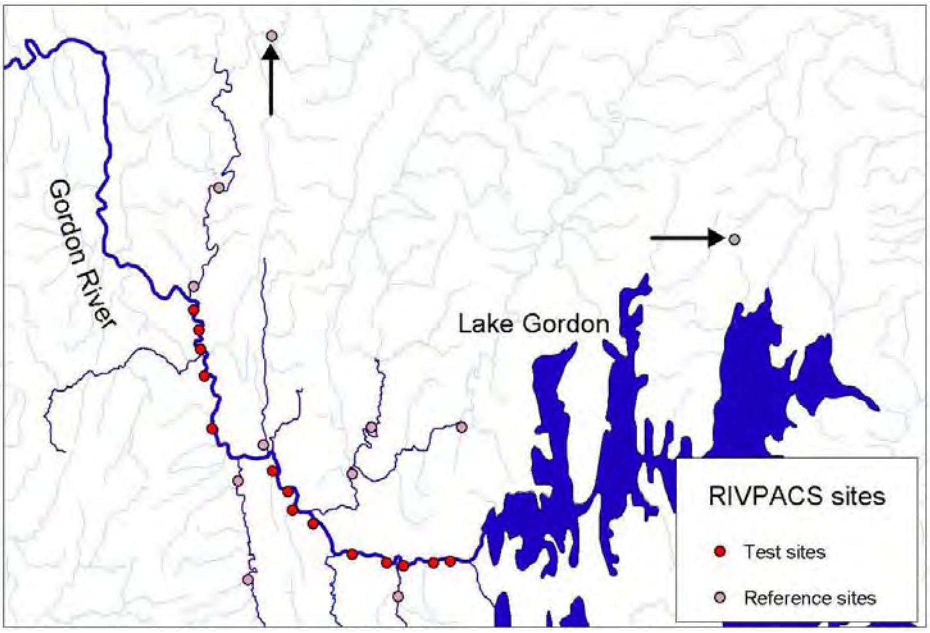
For this study, four major approaches were taken to assess the status of and risks to biological communities and habitat availability/quality:

- A predictive modelling approach to bioassessment called RIVPACS, or the River Invertebrate Prediction and Classification Scheme, which also forms the basis of a national river bioassessment framework for Australia (AUSRIVAS).
- Quantitative sampling of macroinvertebrates to assess changes in community composition and abundance, as well as to assess the presence of any threatened macroinvertebrate species.
- Habitat-flow analyses using an assessment tool known as IFIM, or the Instream Flow Incremental Methodology. IFIM can be utilised to determine relationships between discharge and suitable habitat area for key species or target biota. Suitable habitat area is expressed as an index of habitat availability (Weighted Usable Area or WUA) for key species or target biota, and is plotted against discharge. Davies and Humphries (1996) had developed a risk-assessment approach for determining minimum environmental flows using IFIM-derived and other habitat-flow data, and their approach was used in this study.
- Assessment of shear stress changes on the river bed associated with power station operations, using 'FST' hemispheres.

3.5.3.1.1 Macroinvertebrate Sampling Using RIVPACS

RIVPACS 'rapid assessment' sampling, involving kick-net sampling in riffle environments in the Gordon River during conditions with the power station off, was conducted during spring 1999 (Nov-Dec) and autumn (Mar) 2000. Fourteen sites were sampled in the Gordon River ('test' sites), as well as thirteen sites sampled in Gordon River tributaries (unregulated 'reference' sites). One kick sample was taken per site, and sample residues were kept to be identified to family level.

Data from the kick net sampling was analysed using two RIVPACS predictive bioassessment models developed for the Hydro catchments by Davies *et al.* (1999). These models were used to generate an 'O/E' index, ranging from 0 (extremely impacted) to around 1 (unimpacted and equivalent to reference condition), for each test site sample. O/E is the ratio of the number of taxa found at a river site (O = observed) to the number of taxa predicted for that site in the absence of disturbance (E = expected). The predictions are based on a large macroinvertebrate and environmental database derived from unimpacted reference sites sampled from unregulated streams across Tasmanian Hydro catchments.



Map 3.7 RIVPACS reference and test sites.

Two models were developed by Davies *et al.* (1999), one using presence/absence data and one using relative (rank) abundance. These allow differentiation of impacts which cause loss of taxa from those which also cause changes in relative abundance of macroinvertebrates at a site. Thus, O/E_{pa} is an index of the proportion of expected taxa that are present at a site. O/E_{rk} is an index of the extent to which rank abundance categories of the taxa expected to be at a site are present, and is more sensitive to the impacts of flow disturbance than O/E_{pa}.

Table 3.4 Bands for the Hydro O/E_{pa} (presence/absence) and O/E_{rk} (rank abundance) RIVPACS models developed by Davies *et al.* (1999).

Band	Bounds O/E_{pa} model	Bounds O/E_{rk} model	Description
X	**> 1.15**	**> 1.11**	More diverse than reference*
A	0.79 – 1.15	0.78 – 1.11	Equivalent to reference. *Unimpacted.*
B	0.43 – 0.79	0.44 – 0.78	Less diverse than reference. *Significantly Impacted.*
C	0.07 – 0.43	0.10 – 0.44	Much less diverse than reference. *Highly Impacted.*
D	0.000 – 0.07	**0.000 – 0.10**	Extremely less diverse than reference. *Extremely impacted.*

* may occur for sites of exceptional natural diversity, or due to slight nutrient enrichment.

3.5.3.1.2 Quantitative sampling

Quantitative (‘surber’) samples were also taken at each site to assess changes in macroinvertebrate abundance between sites downstream of the power station, which cannot be done using kick samples.

Sampling of exposed channel sediments was also conducted following power station shutdowns in order to assess the significance of macroinvertebrate stranding following rapid flow declines.

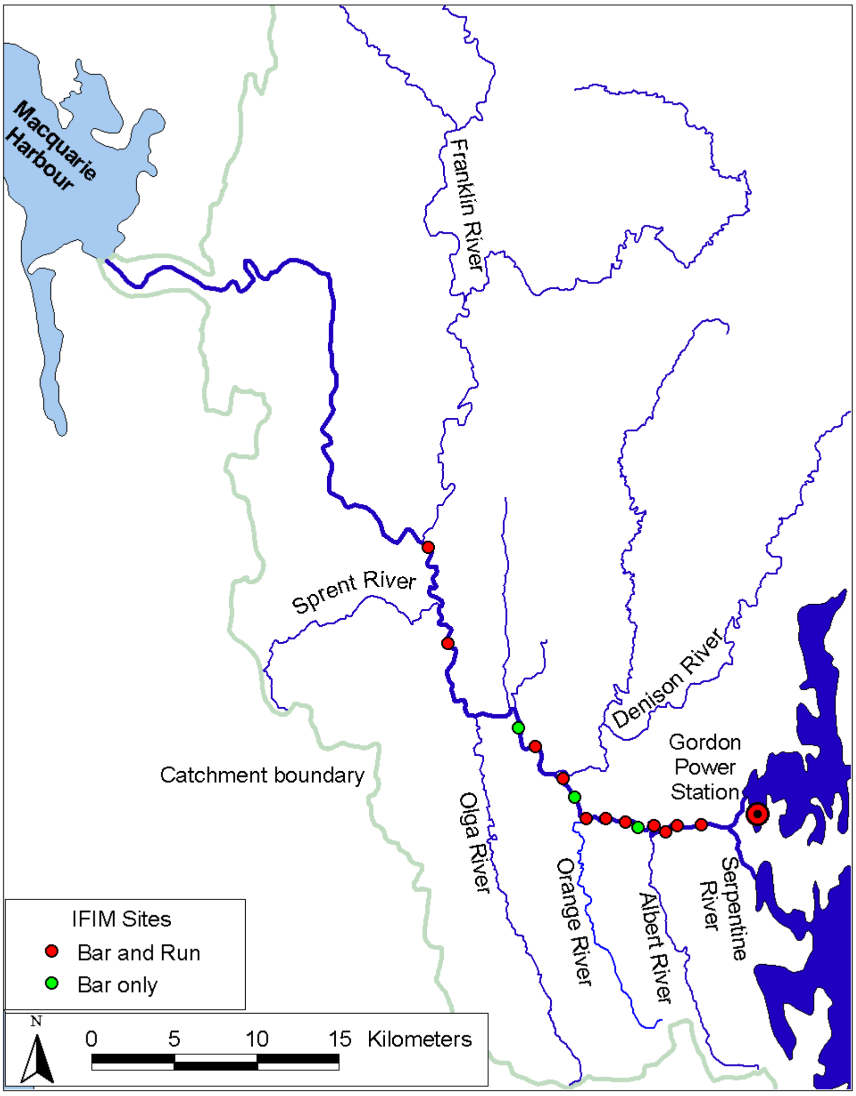
Selected quantitative and kick samples were identified to species level to assess the presence of species listed under the *Threatened Species Protection Act* 1995.

3.5.3.1.3 Habitat-Flow Analyses using IFIM

The habitat availability analyses utilised two sets of data – hydraulic data collected in field surveys from representative transects across the river, and habitat preference data for key aquatic taxa (macroinvertebrates, fish and platypus) derived either from the literature and/or from field sampling.

Hydraulic data for the IFIM analysis were collected at sixteen bar cross-sections in the Gordon River, largely coincidental with the sites used for RIVPACS sampling (riffles at low flow), as well as at adjacent pool-run reaches. Map 3.7 and Map 3.8 show the locations of the RIVPACS and IFIM sampling conducted for this study. Hydraulic data collected included velocities, depths, substrate descriptors and cover (for fish) at between 27 and 89 locations across each cross-section. Hydraulic data was collected at low flow (power station off) at all sites, and at high flow (power station on) for those sites which could be safely accessed. Rating curves were developed for transects over a wide range of discharges between power station off and power station on, so that velocities and depths could be simulated over those discharges.

Habitat preference data for this study was derived from available data, literature review, expert interviews (for platypus), and from sampling in the Franklin River, for macroinvertebrates. This latter involved quantitative 'surber' sampling of macroinvertebrates from the lower Franklin River upstream of Big Falls, a reach of similar channel dimensions and slope to the Middle Gordon River, without the impact of flow regulation.



Map 3.8 IFIM Study sites.

Discharge data was provided by Hydro Tasmania for each transect site for the period 1977-1999 for natural, historical and Basslink scenarios. Detailed flow analyses were undertaken using 1997-1998 hourly data, with 1998 being utilised because it has the better record of the two years for which hourly data is available, and it was an 'average' year in terms of water yield and seasonal behaviour.

For this study, habitat availability ('WUA' in m^2 area/m of river channel) was determined at different discharges (Q) for 9 taxa or variables including wetted area, platypus abundance, key invertebrate taxa (caddisflies, mayflies, janirid isopods, blackflies, midges), number of macroinvertebrate taxa (as a measure of diversity), and total invertebrate abundance. Plots of WUA-Q were generated at three locations in the Middle Gordon River – Site 75 (~ 3 km downstream of the tailrace), Site 63 (u/s of the Denison River, and Site 42 (u/s of the Franklin River). For locations, see Map 3.4 in Section 3.2.1.4.

3.5.3.1.4 Shear Stress Assessments

High shear stress (force applied to the stream bed) is associated with faunal displacement and possibly bed movement under rapidly varying flows. Field experiments were conducted by placing hemispheres of known densities on the stream bed and observing their movement by the changing flow. These experiments required diving, and because of safety issues with the high Gordon River flows were conducted in the King River downstream of the John Butters Power Station. Results showed no indications of any major shift in patterns of rising or falling shear stress associated with rising or falling discharge during hydropeaking flow pulses, other than that associated with changes in water velocity. There were therefore no significant implications for management of ramping rates, and this issue was not pursued further in this study.

3.5.3.2 Present Status

3.5.3.2.1 Main Habitat Types

The instream habitats of the Middle Gordon River are dominated by long pool-runs, interspersed with shingle bars or bedrock rapids. Pool-runs are characterised by long pools of open water, with a uniform cobble-boulder substrate and sand deposits lateral to the channel, and snags (large woody debris) lining the banks. Shingle bars are characterised by cobble and small boulder beds overlaying mixed cobbles, sand and gravel. Rapids are often formed by banks or bars of limestone, although boulder and slab rapids are often associated with the major gorges found in the Middle Gordon River. There are also some lateral side channels and pools found in the Middle Gordon River, but these comprise only a small proportion of total riverine habitat.

Table 3.5 summarises the percent of habitat types present in the different reaches of the Middle Gordon River. Dominance of the pool-run habitat is very evident from this table.

Table 3.5 Main habitat type as percent of total channel area, by river length for the Middle Gordon River.

Reach	Length (km)	% Pool-Run	% bar	% rapids (bedrock/boulder)
Power station - Albert R	5.0	71.5	13.1	15.4
Albert R - Orange R	7.0	57.7	20.4	21.8
Orange R - Denison R	6.0	78.9	8.8	12.3
Denison R - Olga R	7.1	75.9	7.8	16.3
Olga R - Sprent R	5.1	86.2	12.1	1.7
Sprent R - Franklin R	5.5	89.1	8.0	3.0

Figure 3.12 shows a typical bar channel profile for Site 75, downstream of the tailrace. Water levels associated with natural baseflows are shown as dashed blue lines, and present power station operations as solid green lines. Light green lines on the bank indicate an observed algal ‘ring’, a band of filamentous algae (*Mougetia* sp.) growing on hard surfaces (cobble, bedrock or snags) below the high water mark, also observed downstream of other hydro-peaking stations including downstream John Butters. Positions of riparian vegetation and snags are included. The scale is in metres relative to a transect datum peg, and there is considerable vertical exaggeration.

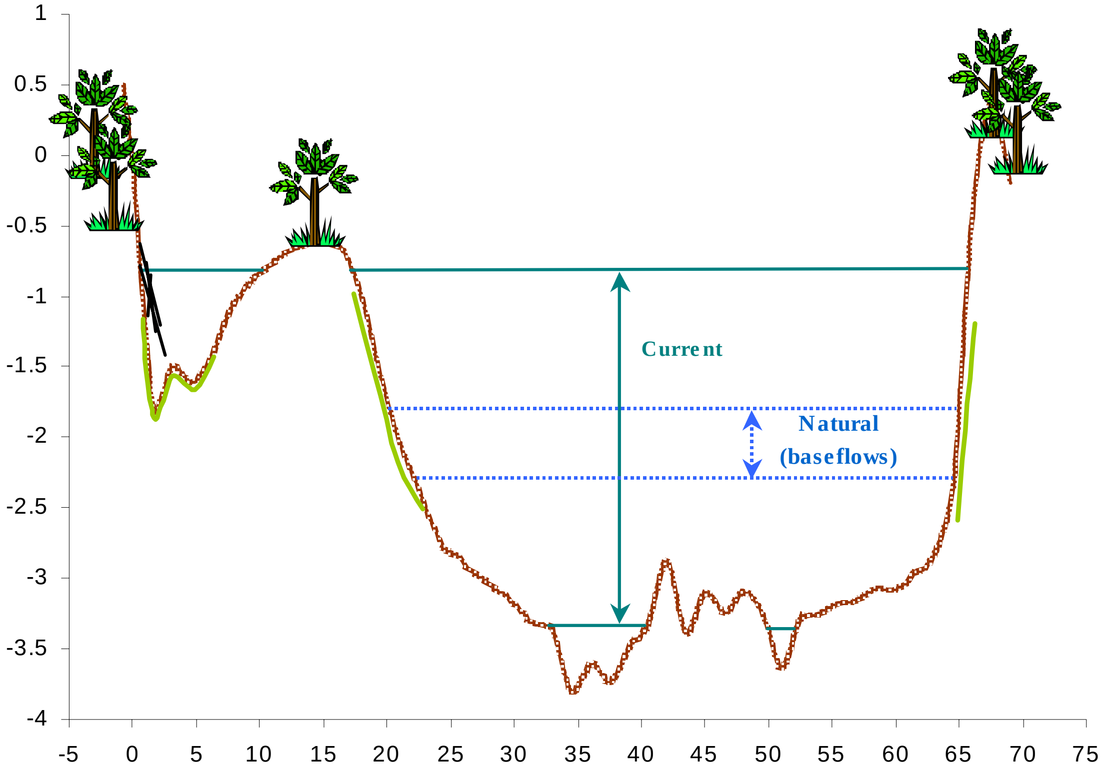


Figure 3.12 Bar channel profile at Site 75, with vertical exaggeration.

3.5.3.2.2 Present Status of the Macroinvertebrate Fauna

The macroinvertebrate fauna of the Middle Gordon River is characterised by high abundances of aquatic insects, particularly mayflies, caddisflies and blackfly larvae, as well as freshwater worms and crustaceans (isopods and amphipods). This community was described by both Coleman (1978) and Davies *et al.* (1999) for the lower reaches of the Middle Gordon River. It is broadly similar to that observed in other large rivers in the catchment, and the general functional aspects of this fauna have not been substantially altered downstream of the Olga River as a result of power station operations, although the species composition may well have been altered. Based on RIVPACS models, the overall existing structure, abundance and diversity have been significantly affected upstream of the Denison River as a result of power station operations, and also appear to be affected between the Denison and Sprent Rivers since dam construction.

Table 3.6 shows the O/E ratios for all the Middle Gordon River sites sampled for this study (see Map 3.4 for site locations). The pattern of O/E ratios from the 1999-2000 data is essentially the same as observed from the 1995-96 data. Upstream of the Denison River, there is a mean of 5.5 taxa fewer than expected under unimpacted (reference) conditions, out of 15 predicted taxa. Sites downstream of the Denison River contain the majority (>75%) of those taxa predicted to occur under unimpacted conditions, but fall within the lower section of the reference or A band, and were also statistically significantly depauperate (with a mean of 1-2 taxa fewer than expected).

Table 3.6 O/E values for all Middle Gordon River sites RAP sampled for macroinvertebrates in 1999/2000.

	Site	O/E pa	O/E rk	Band (pa)	Band (rk)
Tailrace	76	0.504	0.407	B	C
	75	0.573	0.539	B	B
Abel Gorge	73	0.787	0.665	B	B
	72	0.700	0.600	B	B
The Splits	69	0.503	0.440	B	C
	63	0.799	0.638	A	B
Denison R.	62	0.933	0.954	A	A
	60	0.861	0.804	A	A
	58	0.777	0.799	B	A
Olga R.	50	0.907	0.949	A	A
	48	0.765	0.676	B	B
Franklin R.	42	0.955	0.990	A	A

3.5.3.2.3 Conservation Status

Six species are listed from the Gordon River catchment under the *Threatened Species Protection Act* 1995, comprising two snail species, a stonefly, and three caddisfly species, all classified as rare. None of these species are listed as occurring in the Gordon River itself, and none are listed as threatened or endangered. None of these listed species were found in the collections of larval material undertaken in this study. Therefore there are not considered to be any significant threatened species issues in the Middle Gordon River with respect to macroinvertebrates.

3.5.3.2.4 Habitat-Flow Relationships

The key effects of the present flow regime with regard to macroinvertebrate fauna are:

- periodic dewatering and exposure of river bed on bars and the lower margins of banks result in losses of substantial areas of habitat compared to under natural flow conditions;
- major reductions in the quality and/or loss of edge and snag habitats through dewatering and/or bank erosion; and
- rapid fluctuations in water velocity and depth.

Plots of weighted usable habitat area (WUA) versus discharge for key taxa show that the taxa most sensitive in WUA to changes in flow are hydrobiosid caddis, leptophlebiid mayflies and simuliids (blackflies). Figure 3.13 shows the weighted useable area (WUA) for dominant macroinvertebrate taxa and maximum macroinvertebrate abundance and taxon richness against discharge for bar habitat downstream of the tailrace. Peaks in habitat availability (WUA) at low to moderate discharges are common to many of the taxa.

The general trends for most of the key macroinvertebrate taxa under existing conditions are:

- declining habitat availability at very low flows (typically less than 10-20 m^3/s) for most taxa in bar habitats;

- peaks in habitat availability at low to moderate flows in both bar and pool-run habitats; and
- decreases or plateaux in habitat availability at high flows (typically greater than 100 m^3/s).

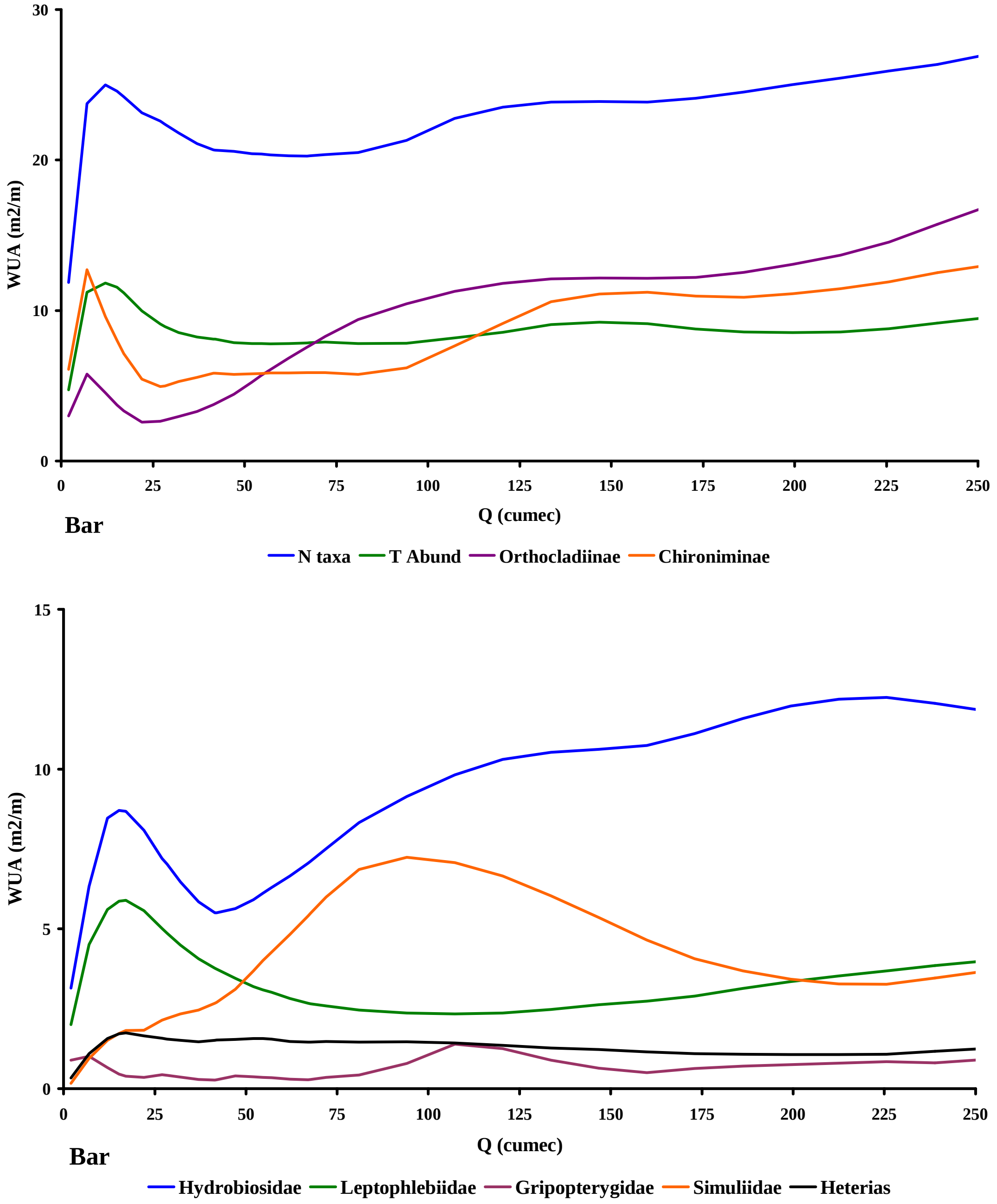


Figure 3.13 Plot of weighted useable area (WUA) for dominant macroinvertebrate taxa and maximum macroinvertebrate abundance and taxon richness against discharge for *bar* habitat at study reach 03 (downstream of the tailrace).

3.5.3.2.5 Within Channel Community Distributions

Under the present flow regime, minimum flows have declined significantly compared to natural conditions, but these have been offset by prolonged periods with higher flows. The reduced minimum flows have resulted in a reduction in the area of the wetted stream bed that does <u>not</u> experience a significant dewatering event. The prolonged periods with higher flows have resulted in some areas of the channel being wetted for periods up to 3-7 months of the year.

These flow patterns have resulted in a three broad 'zones' within the channel cross-section:

- the thalweg zone - a permanent macroinvertebrate community is positioned along the thalweg (point of deepest water in the channel) which is reduced in abundance and diversity compared to natural;
- The 'lower intertidal' zone - the lower part of bank and bars on which a biofilm and macroinvertebrate community is successfully established for several months of the year, prior to dewatering occurring leading to emigration and/or stranding and mortality; and
- The 'upper intertidal' zone – the upper portion of the bank where macroinvertebrates and biofilms, are absent other than some resistant algae.

3.5.3.2.6 Present Conditions - General Conclusions

Overall, the Middle Gordon River downstream of the Denison River contains a macroinvertebrate assemblage broadly similar to those in other rivers of the Gordon catchment. However, as a result of both historical and present regulated flow discharge patterns, the Middle Gordon River has experienced significant biological impacts to this macroinvertebrate assemblage, with:

- substantial decreases in instream macroinvertebrate diversity and abundance; and
- shifts in community composition of macroinvertebrates.

Most of the alterations in the Middle Gordon occurs in the reach upstream of the Denison River, which is at present significantly to severely biologically depauperate. However, the data also indicates some reduction in macroinvertebrate diversity and abundance downstream of the Denison River as far downstream as the Franklin River junction.

At present, there are no threatened species issues in the Middle Gordon (as defined under the Tasmanian *Threatened Species Protection Act* 1995) for aquatic invertebrates or vertebrates.

3.5.3.3 Potential Basslink Changes

The key aspects of the Basslink flow regime which will result in impacts for the existing macroinvertebrate communities of the Middle Gordon River are:

- a shift to an even more variable flow regime, with rapid cycling of river levels, interspersed with higher flows;
- an extension to that area of river channel repeatedly exposed to frequent rapid cycles of wetting and exposure (ie the 'intertidal' zone); and
- a further, significant reduction (30-50% u/s of Denison R., 15-50% d/s of Denison R.) in area of wetted stream bed that does not experience a significant dewatering event.

Increases in flow variability will result in greater frequency of rapid fluctuations in shear stress at the bed, causing the permanent community residing along the thalweg to be further reduced in abundance and diversity.

The additional area of river channel repeatedly exposed to rapid cycles of wetting/exposure will result in a downward extension of the present intertidal zone which is characterised by little biological value.

As a consequence under Basslink, the within-channel macroinvertebrate community structure described in Section 3.5.3.2.5 will shift from a three-zone to a two-zone system, with a loss of the 'lower intertidal' zone, leaving:

- the channel centre or thalweg zone, with a permanent macroinvertebrate community and biofilm that will experience further decreases in diversity and abundance; and
- a broader 'intertidal' zone with no or very few macroinvertebrates, other than those which become stranded, and little or no biofilm other than some resistant filamentous algae.

The flow regime under Basslink is anticipated to result in further decreases in diversity and abundance of macroinvertebrates throughout the middle Gordon. This would be more significant in Section 1 upstream of the Denison River, but would also occur throughout Section 2, downstream of the Denison River.

Overall, the researchers conclude that the forecast flow regime under Basslink, with no provision for minimum flows or other mitigation, will result in:

- Upstream and downstream of the Denison River – further loss of aquatic macroinvertebrate fauna in bank and edge habitats, and in upper elevation portions of the bed of the Gordon River due to repeated dewatering, absence of biofilm, and stranding;
- Upstream of the Denison River – further reduction in abundance and diversity of macroinvertebrate fauna in areas of river bed that remain wetted during low flows (ie along the 'thalweg') due to frequent, rapid and intense fluctuations in depth, velocity and hence shear stress. Thalweg O/E values are anticipate to fall by around 0.2-0.3, mostly into the 'C' or severely impacted band;
- Downstream of the Denison River - further reduction in the quality of channel margins and snags as habitats due to enhanced level fluctuations. These would be exacerbated if erosion and localised sand movement are enhanced under Basslink (see Section 3.3 and Appendix 4). Further reduction in thalweg macroinvertebrate diversity is anticipated, with O/E value falling by around 0.1 into the 'B' or significantly impacted band.

3.5.3.4 Mitigation Options

3.5.3.4.1 An Environmental Flow Regime

The only major option available for mitigation of Basslink impacts on the macroinvertebrate fauna of the Middle Gordon River is through management of flow releases for environmental purposes. In theory, this could be done through power station discharges, or releases from the Gordon or Serpentine dams, or by provision of a re-regulating structure (a dam or weir which impounds the regulated flows from the power station, and allows control over release patterns to downstream of the structure). Two key elements of the flow regime are identified in Appendix 7 for partial mitigation of Basslink (and present) impacts – minimum flows, and flow ramping.

3.5.3.4.2 Minimum Flows

The objective of a minimum flow for the Middle Gordon River is to ensure that there is a proportion of channel that is permanently inundated and that maintains a modified but not highly depauperate macroinvertebrate community when the power station is not discharging. Under the predicted Basslink flow regime, provision of a minimum flow would minimise the projected impacts on the thalweg communities by providing a greater habitat area for the permanent thalweg macroinvertebrate community, and would also dampen shear stresses on the bed, particularly on the rising limb of the hydrograph by reducing water surface slopes.

Minimum environmental flows were assessed using a risk assessment described by Davies and Humphries (1995), where habitat losses for all taxa (macroinvertebrates, fish and platypus) are minimised relevant to a reference flow. The reference discharges chosen for this study were natural 'baseflows' during summer-autumn and winter-spring in an average year, 'baseflow' being the term that describes the discharges between significant rain events. Median reference flows at the three middle Gordon sites (see Map 3.4) were as follows:

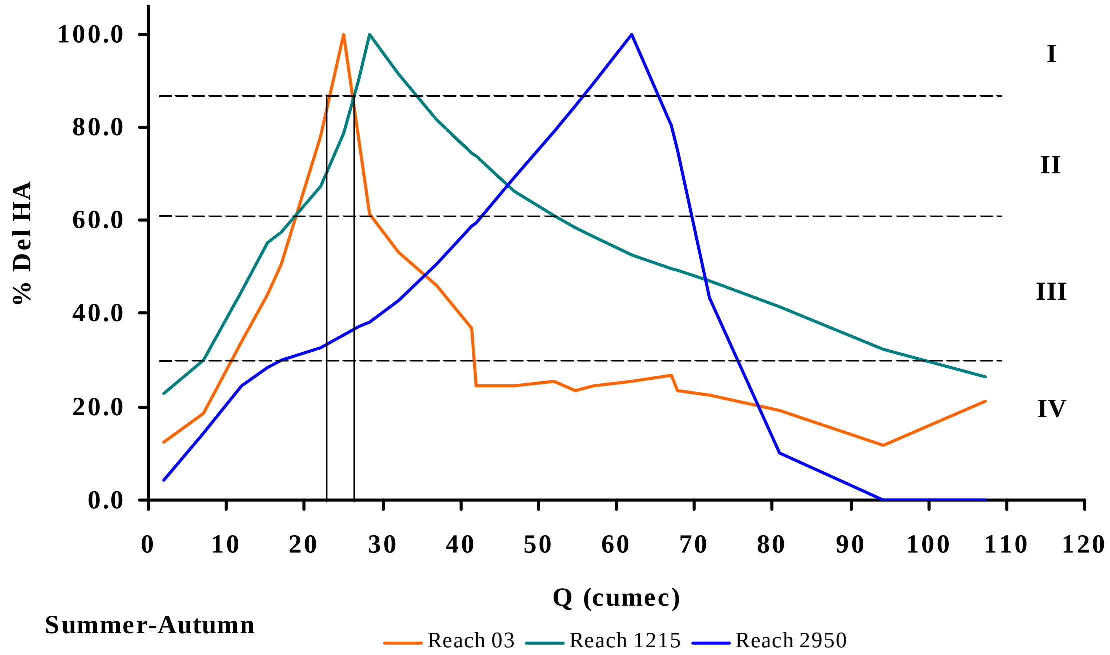
- Site 75: 25 m^3/s for summer-autumn, 50 m^3/s for winter-spring;
- Site 63: 28 m^3/s for summer-autumn, 55 m^3/s for winter-spring; and
- Site 42: 60 m^3/s for summer-autumn, 95 m^3/s for winter-spring.

The percent of deviation of the measured habitat availability (WUA) from that expected under natural conditions (ie at the reference flow) was determined (expressed as %ΔHA) for a number of flows above and below the reference flow. Then each value of habitat deviation was converted to a risk category (Table 3.7), with the risk being the failure to maintain biota due to loss of habitat availability relative to reference conditions (which are natural baseflows). The results for individual taxa were kept separate, and then the final risk assessment was conducted by taking the highest risk score across all biological variables as the overall risk. The lowest discharge associated with that risk was then recommended as a seasonal minimum environmental flow for that site. This approach is inherently conservative (in favour of the fauna). This analysis was conducted for three study reaches, for which hydraulic modelling could be conducted over a full range of flows (i.e. reaches containing transect sites with complete rating curves).

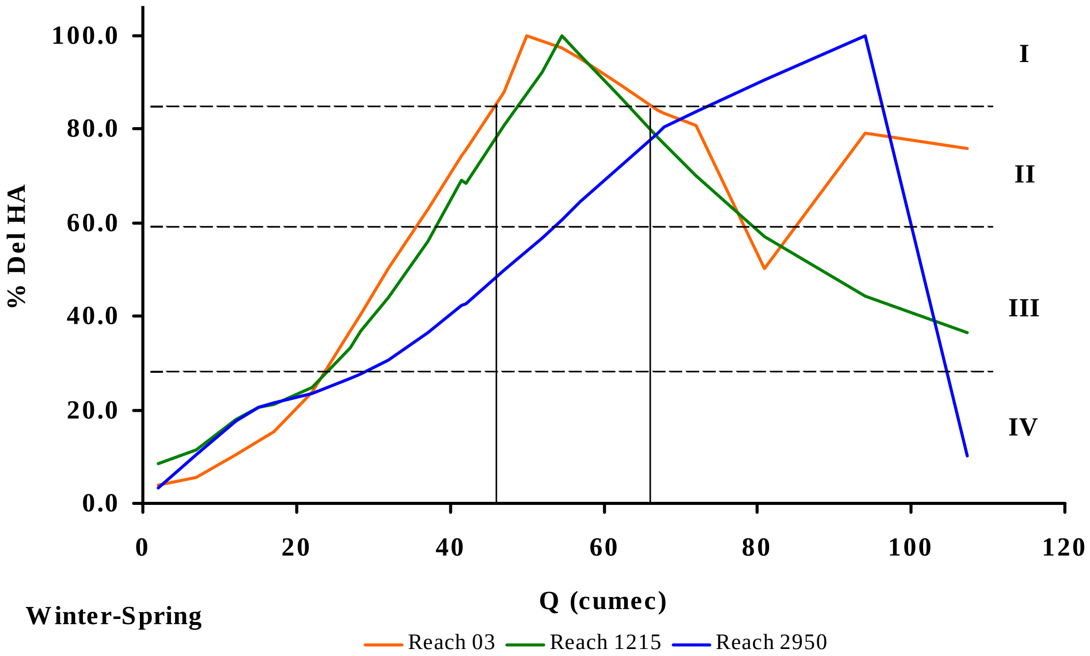
Table 3.7 Risk categorisation criteria for biological values in the Gordon River and values for %ΔHA.

Risk category			
I	**II**	**III**	**IV**
No risk or beneficial	**Moderate risk**	**High risk**	**Very high risk**
> 85% of habitat under natural baseflows	60 – 85% of habitat under natural baseflows	30 - 60% of habitat under natural baseflows	< 30% of habitat under natural baseflows

Figure 3.14 shows a plot of the overall minimum %ΔHA value at each study reach, plotted against discharge for the two seasonal periods. Horizontal dashed lines show bounds for risk categories I – IV as defined in Table 3.7. Study reach designations relate to the kilometre range downstream of the tailrace, with Reach 03 representing a reach 0-3 kilometres downstream of the tailrace, Reach 1215 representing 12-15 km downstream of the tailrace, and Reach 2950 representing 29-50 km downstream of the tailrace. Vertical solid lines show an example of the range of minimum flows for reach 03 associated with risk category I, being between 23-26 m^3/s in summer-autumn, and 46-66 m^3/s in winter-spring.



Summer-Autumn



Winter-Spring

Figure 3.14 Plots of minimum %ΔHA values against discharge for the three Middle Gordon River study reaches.

The degree of environmental risk associated with the different minimum discharge ranges is shown in Table 3.8. This table extracts the target minimum flow ranges for different risk categories and locations from the plots in Figure 3.14, and for each one identifies which taxa experience significant habitat loss relative to the reference flow, being the natural baseflow. For example, a summer-autumn target minimum flow in risk category II, measured in Reach 03, would be between 19 and 23 m^3/s, and would not provide the optimal habitat for two species of instream fauna in comparison with natural flows.

Table 3.8 Risks to instream fauna associated with the adoption of minimum environmental flows of different magnitudes (Q, in m^3/s) for the three study reaches in the middle Gordon.

		I No risk or beneficial	II Moderate risk	III High risk	IV Very high risk
Summer-autumn					
Reach 03	Q	23 - 26	19 - 23	11 - 19	< 11
	Taxa with significant habitat loss		Simuliidae, Ammocoetes	TA, Simuliidae, *Heterias*, Orthoc.	TA, Simuliidae, *Heterias*, Chiron., Orthoc., platypus, Shortfin eel, Ammocoetes, *Salmo trutta* adult (WA)
Reach 1215	Q	26 - 35	19 - 26	7 - 19	< 7
	Taxa with significant habitat loss		Simuliidae, *Heterias*, Leptophlebiidae	TA, Simuliidae, *Heterias*, Leptophlebiidae, Chiron., Orthoc., *S. trutta* spawning. (WA)	TA, NT, Simuliidae, *Heterias*, Leptophlebiidae, Chiron., Orthoc., Hydrobiosidae, *S. trutta* spawning & adults (WA)
Reach 2940	Q	55 - 66	42 - 55	17 - 42	< 17
	Taxa with significant habitat loss		Simuliidae, Orthoc. (WA)	Simuliidae, Orthoc., Chiron. (WA)	TA, Simuliidae, *Heterias*, Orthoc., Chiron., *S. trutta* adults (WA)
Winter-spring					
Reach 03	Q	46 - 66	36 - 46	24 - 36	< 24
	Taxa with significant habitat loss		Simuliidae, *Heterias*	TA, Simuliidae, *Heterias*, Leptophlebiidae, Orthocladiinae	TA, NT, Simuliidae, Leptophlebiidae, *Heterias*, Chiron., Hydrobiosidae, Orthoc., Shortfin eel, Ammocoetes, *S. trutta* adults & spawning. (WA)
Reach 1215	Q	49 - 63	38 - 49	25 - 38	< 25
	Taxa with significant habitat loss		Simuliidae, *Heterias*, Leptophlebiidae	TA, NT, Simuliidae, *Heterias*, Leptophlebiidae, Chiron., Orthoc., Hydrobiosidae, *S. trutta* spawning. (WA)	TA, NT, Simuliidae, *Heterias*, Leptophlebiidae, Chiron., Orthoc., Hydrobiosidae, *S. trutta* spawning & adults, ammocoetes. (WA)
Reach 2940	Q	73 - 96	54 - 73	31 - 54	< 31
	Taxa with significant habitat loss		Simuliidae, Orthoc. (WA)	TA, Simuliidae, Orthoc., Chiron. (WA)	TA, NT, Simuliidae, *Heterias*, Orthoc., Chiron., *S. trutta* adults (WA)

WA = wetted area, NT = number of macroinvertebrate taxa, TA = total macroinvertebrate abundance, Orthoc. = Orthocladiinae, Chiron. = Chironominae, Ammocoetes = early life stage of the lamprey *Geotria australis*.

The researchers recommend a minimum environmental flow in risk bands I and II measured immediately downstream of the tailrace, being maintenance of a 19-26 m^3/s flow through December to May, and 36-66 m^3/s through June to November. Provision of a minimum environmental flow alone is not considered to fully mitigate against Basslink impacts on the macroinvertebrate fauna, as the highly variable nature of the flow will continue to be a primary driver of impact. However it does provide partial mitigation of not only projected Basslink impacts, but also existing effects of Gordon Power Station operations.

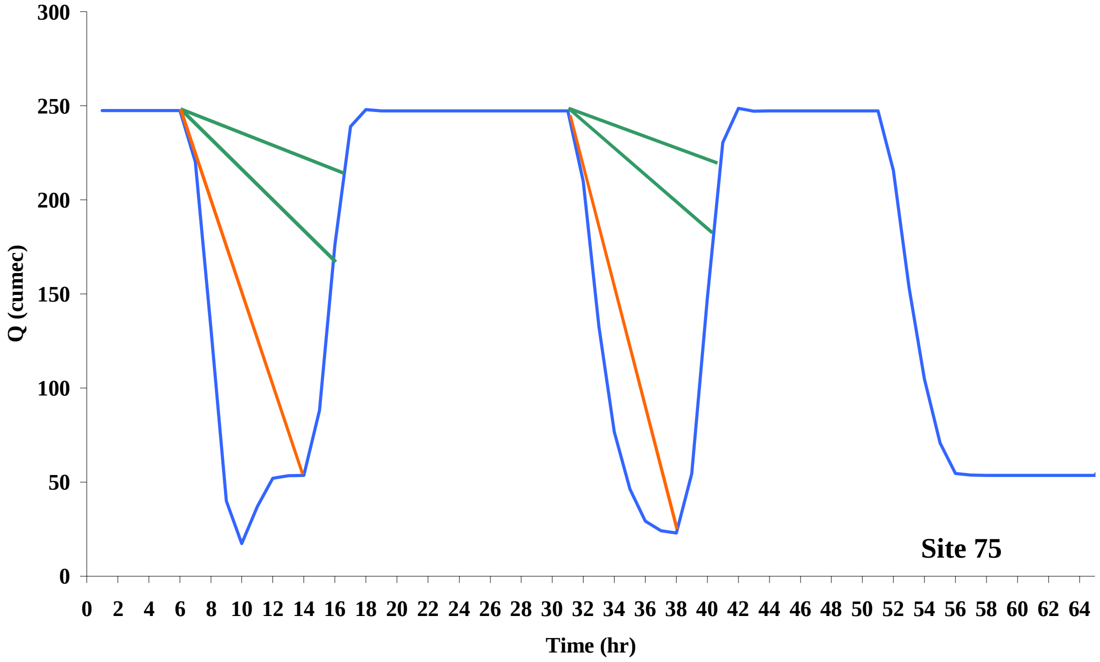
3.5.3.4.3 Flow Ramping

Management of rates of increase and decrease of power station discharge can slow the rates of downstream river level change, and thus reduce incidences of stranding of fish and macroinvertebrates in ‘intertidal’ zones.

Gordon Power Station operations result in rates of rise that are either comparable to or slightly faster than natural flood peak rise rates. However, rates of fall with power station operations are 10-24 times faster than natural flood recession rates.

Figure 3.15 shows discharge peaks associated with power station peakload generation under Basslink at Gordon River Site 75 (4 km downstream of power station) and Site 42 (upstream of Franklin River, 35 km downstream of power station) over a 64 hour period in February 1998. Green lines indicate maximum and minimum natural recession rates for floods of about 300 m^3/s in size, and clearly illustrate that there would be very little fluctuation in power station discharge between demand peaks if these ramping rates were imposed. Orange lines indicate slowest possible ramping rates which still allow full hydropeaking, resulting in rates of decline of between 25-35 m^3/s per hour at both sites.

These rates are still far too fast to provide protection from stranding for even the most mobile of fish species, and so would not be effective as a mitigation option under Basslink operation of the Gordon Power Station. As a consequence, the researchers did not pursue further the option of flow ramping as a potential benefit for macroinvertebrates in the Middle Gordon River under Basslink operation of the Gordon Power Station.



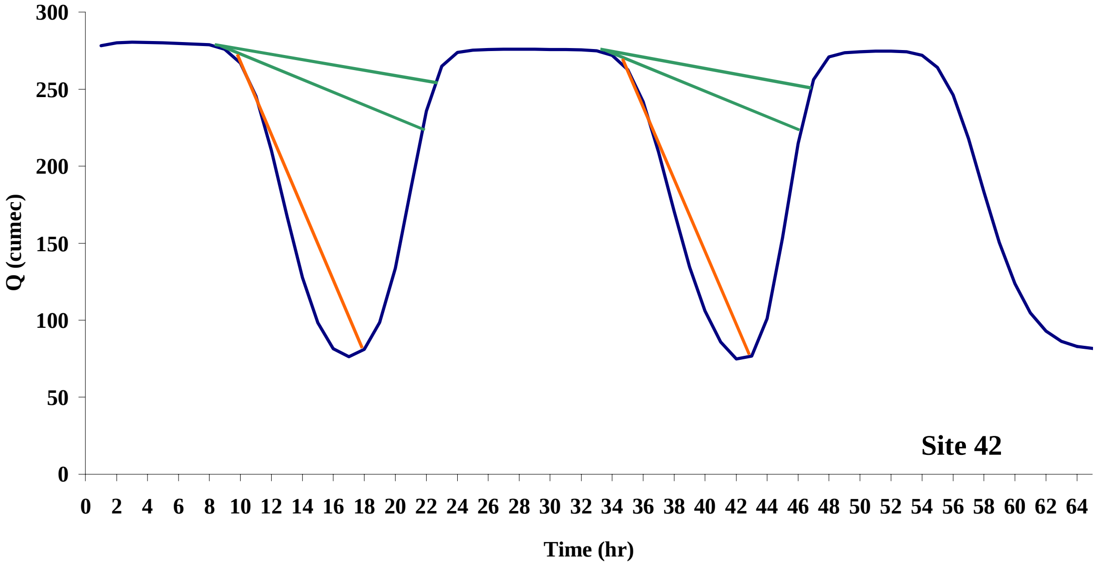


Figure 3.15 Plots of discharge peaks associated with power station peakload generation under Basslink at Gordon River sites 75 and 42 over a 64 hour period in February 1998.

3.5.3.5 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- the monitoring considerations of the individual researchers; and
- the Basslink-related options arising from those considerations.

3.5.3.5.1 Researchers' Monitoring Considerations

The authors of this study (Appendix 7) suggested macroinvertebrate monitoring in spring and autumn, at eight Gordon River sites and six reference sites, using comparable methods to the present study. Resultant data are to be analysed by ANOVA, with the time*location interaction term (at an alpha of 0.05) used to assess the significance of any changes. These analyses should be conducted separately by section within the Middle Gordon.

The study also suggested concurrent algal monitoring at seven Gordon River sites. Statistical analysis will comprise paired t-tests between years. These analyses will be conducted separately for filamentous algae, moss and characeous algae.

3.5.3.5.2 Basslink-related Monitoring Options

Both of the above monitoring suggestions will provide important information on Basslink-related changes and subsequent mitigation measures. Although no time period was specified in the report, a six-year timetable, based on three years pre- and three years post-Basslink has been included in the Gordon Basslink Monitoring Program (Section 3.10).

3.5.4 Gordon River Fish

The Gordon River Fish Assessment was conducted by Howland, Davies, Blühdorn and Andrews, and is reported on in full in Appendix 8.

3.5.4.1 Background Information

Prior to this study, there were very few data available on the fish fauna of the Gordon River. No fish surveys were specifically undertaken as part of the Lower Gordon Scientific Studies (Christian and Sharp-Paul 1979). Some limited surveys were conducted in the Lower Gordon River by the Inland Fisheries Service in the late 1980s, showing the composition of whitebait runs and the presence of trout. Whitebait runs are the upstream migrations of juvenile galaxias (native Tasmanian fish) and other fish species, which occur in the lower reaches of Tasmanian rivers during late winter through to early summer. Whitebait runs in the Lower Gordon River were shown to be comprised of juvenile *Galaxias maculatus* (the common jollytail), *G. brevipinnis* (climbing galaxias), *G. truttaceus* (spotted or 'mountain' galaxias), and *G. cleaveri* (Tasmanian mudfish). Trout catches showed a significant population of introduced brown trout (*Salmo trutta*), with occasional catches of rainbow trout (*Oncorhynchus mykiss*) and Atlantic salmon (*Salmo salar*) which were probably escapees from Macquarie Harbour fish farms.

From observations of fish populations in other Tasmanian rivers, it would be expected to find deeper pool-run habitats dominated by larger brown trout and eels (*A. australis*), with native fish and juvenile brown trout dominating the channel margins of pool-runs or the shallower riffle habitats. Tasmanian rivers also tend to have the highest abundance of migratory native fish (galaxiids, etc) in the lower reaches, closer to tidal waters, and highest abundance of brown trout and eels in the upstream reaches. The Australian grayling would be expected in the lower reaches of the Gordon River, and has been previously observed in the Lower Gordon River at and downstream of the Franklin River confluence.

3.5.4.2 Methods

This study was largely based on field fish surveys. After testing a range of methods, backpack electro-fishing was selected as the standard sampling method. It is widely used as a standard method, allows for a repeatable approach with minimal mortality rates, and has known biasses, and offer a method for comparison between sites.

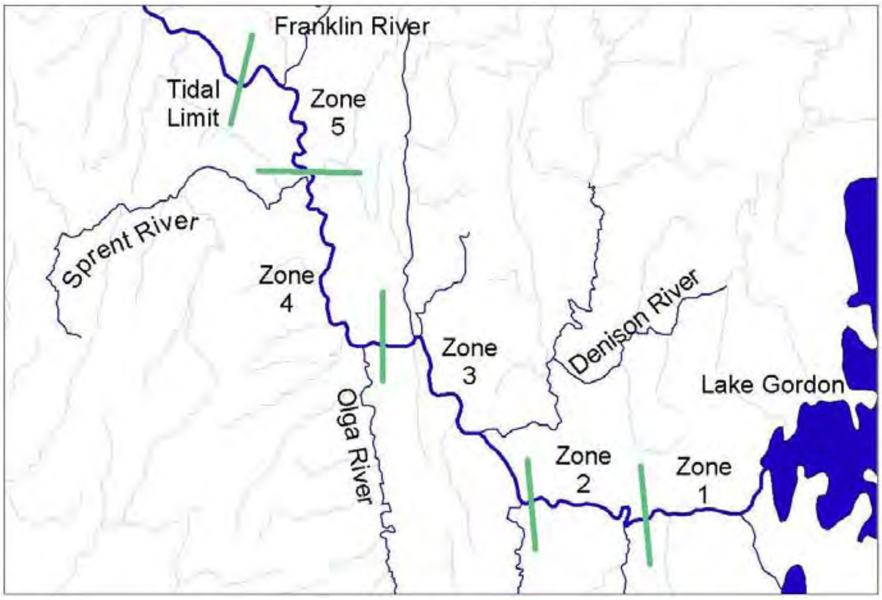
Numerous sites were sampled in the Gordon River (22 sites), in tributaries of the Gordon River (Serpentine, Albert, Orange, Denison, Smith, Olga, Sprent, and Franklin rivers; and Piguenit, Splits, Platypus, Harrison, Howards, and Grotto creeks), and in three catchments outside of the influence of the Gordon River (Davey River, Henty River, and Sorell River catchments).

Results were standardised into a comparative Catch Per Unit Effort (CPUE) figure for each visit to each site, using specialised queries written into a Microsoft Access database. Site ordination, ANOVA and other statistical analyses were conducted using PRIMER and Microsoft Excel using CPUE summaries.

An Instream Flow Incremental Methodology (IFIM) study was undertaken to calculate habitat availability for selected fish species, using previously developed habitat preference curves. This is similar to the methodology described in the previous section for the macroinvertebrate study.

3.5.4.3 Present Distributions of Fish in the Middle Gordon River

The fish community structure of the Gordon River varies longitudinally. This was anticipated from the background information (Section 3.5.4.1), but also physical barriers to fish migration in the river system play a significant role. For this reason, the fish study divided the Middle Gordon River into five "fish zones" divided by significant barriers to fish migration (Map 3.9), with Zone 1 being closest to the power station and Zone 5 ending at the Franklin River. These barriers are the Sprent River delta, Ewarts Gorge, the Splits, and Abel Gorge.



Map 3.9 Fish zones.

Summaries of the fish species found in this study and the catch rates are shown in Table 3.9 for the Middle Gordon River, and Table 3.10 for the Gordon River tributaries. Zones are indicated in these tables to assist discussion.

Table 3.9 CPUE summary for Gordon River zones (pooled samples – river sites).

Zone	*A. australis*	*G. australis*	*G. brevipinnis*	*G. maculatus*	*G. truttaceus*	*M. mordax*	*P. urvillii*	*S. trutta*
1								0.35
2								3.22
3	1.07	0.30						4.42
4	6.85	0.65			1.96			1.63
5	4.15	1.61	0.12	0.12	2.53	0.23	2.07	0.35

Table 3.10 CPUE summary for Gordon River zones (pooled samples – tributary sites). Note: no tributaries were sampled in Zone 5.

Zone	*A. australis*	*G. australis*	*G. brevipinnis*	*G. truttaceus*	*M. mordax*	*P. urvillii*	*S. trutta*
1	0.34		1.72				0.34
2					0.12		1.87
3	0.43	0.13		0.09	0.04		6.81
4	1.31			2.91		0.15	4.80
5	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Several species were found present in addition to those previously recorded (summarised in Section 3.5.4.1), and were *G. maculatus* (galaxiid), *M. mordax* (ammocetes), and *P. urvillii* (sandy).

Brown trout, eels and climbing galaxiids (*G. brevipinnis*) are the only species found in Zone 1, with eels and *G. brevipinnis* only found in the tributaries of Zone 1. The Catch per Unit Effort (CPUE) for brown trout in Zone 1 was the same in the Gordon River as in the tributaries.

Brown trout and eels are also the only species found in Zone 2, upstream of the Splits, and once again the eels were found in the tributaries in this zone and only brown trout was found in the Gordon River itself.

The diversity of species increases noticeably downstream of the Splits, with the highest diversity found in Zone 5, consistent with expectations from other Tasmanian rivers and the general observation that the number of fish species increases with catchment area.

Results for the three most abundant species – short-finned eels (*A. australis*), the spotted galaxias (*G. truttaceus*), and brown trout (*S. trutta*) - are summarised in Figure 3.16.

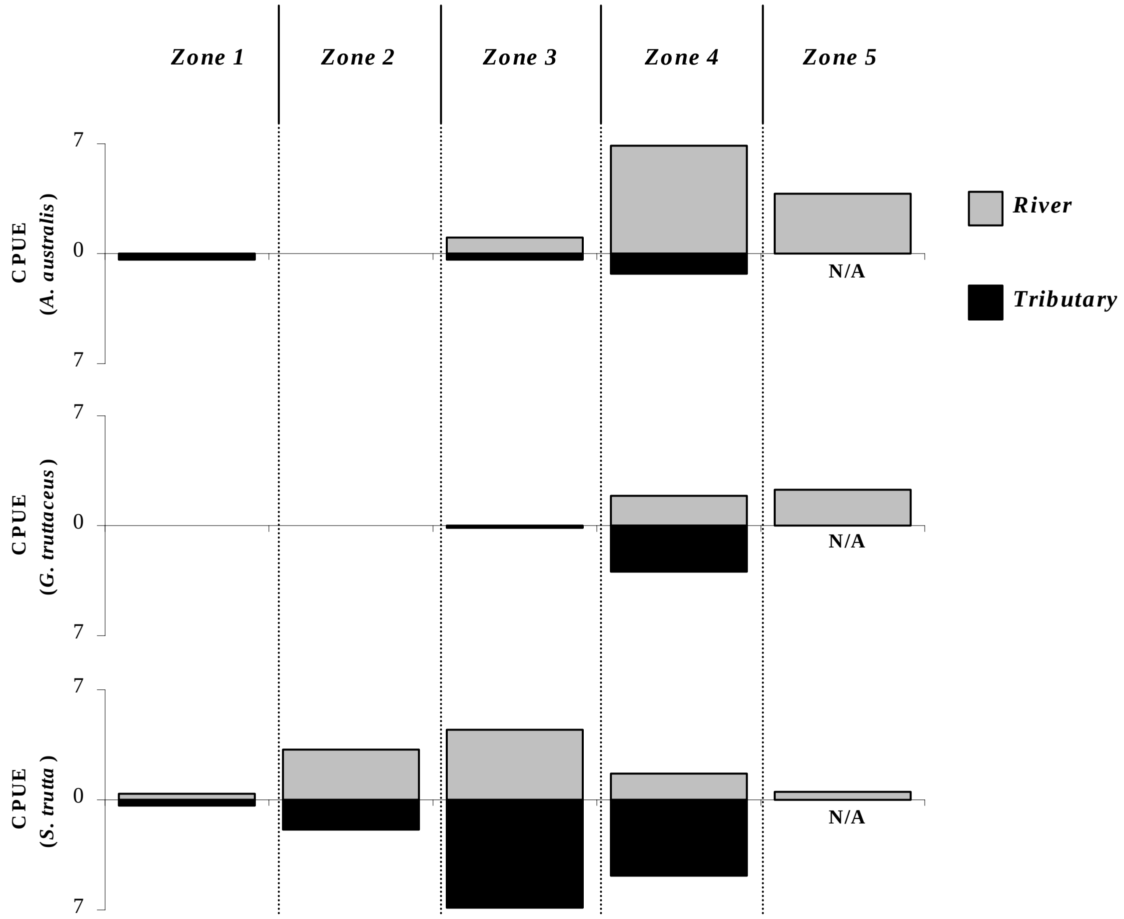


Figure 3.16 Zone CPUE summary for abundant species.

Eels were reasonably abundant in Zones 4 and 5, and most eels captured were juveniles. Zone 3 eel populations were significantly reduced in comparison with the downstream zones. No eels were found in Zone 2, between Abel Gorge and the Splits. One eel was found in Zone 1, an adult in the Serpentine River, most likely indicating that eels have been able to migrate to upstream of the Splits at some time in the past (the alternative would have been via the Serpentine Dam valve, which is considered unlikely). There is a general increase in size of captured eels with distance upstream, showing an older population in the upstream zones that are not regularly supplied by juvenile recruitment from downstream.

Galaxias truttaceus shows similar distributional patterns to the eels, with larger fish upstream and in the tributaries, and abundant juveniles in the lower reaches. There was an absence of this fish in Zones 1 and 2 showing an inability of this fish to migrate past the Splits. The high flows caused by the Gordon Power Station during spring and summer under existing operations would have increased flow velocities to a point where no fish would be able to get through during this important migratory period. *G. brevipinnis* and *A. australis* are found in tributaries upstream of the Splits, probably utilising their ability to climb wet surfaces and stronger swimming abilities during windows of opportunity.

Brown trout were by far the most abundant fish in the upper reaches of the Gordon River and its tributaries. It is present in Zones 1 and 2 in both the Gordon River and its tributaries. The large catches in Zone 3 are largely associated with surveys in the Denison River, which is dominated by trout. Decreasing CPUE for trout with distance downstream from Zone 3 may be a function of river size and ability to effectively sample these areas, or may reflect the decreased influence of power station operations, or may be largely natural (more natives so proportionally less trout as one approaches the tidal limit). Trout are in relatively low numbers in Zone 5.

3.5.4.4 Conservation Status of Gordon River Fish

All fish species found in the middle and Lower Gordon River are common and abundant in Tasmanian rivers, and none are listed under the *Threatened Species Protection Act* 1995, with the exception of the Australian grayling (*Prototroctes maraena*). This species is considered widespread in Tasmania, although low in abundance. The Australian grayling was not found during the Basslink investigations of the Gordon River and its tributaries, although the fish surveys did not target the most likely areas for this species (e.g. downstream of the Franklin River). The absence of observations of grayling in the Lower Gordon River is not reason to believe that the grayling is absent. It has been previously recorded as far upstream as the Franklin River confluence. This fish species inhabits big river sites that are hard to sample quantitatively, and its inherent rarity and elusive nature make it difficult to observe.

3.5.4.5 Summary of Present Condition of Gordon River Fish

The surveys showed that the Gordon River, particularly between the Olga River and the Gordon Dam, has been substantially modified from natural conditions with respect to fish fauna. The regulated flow regime is a major factor controlling the existing community structure in the Middle Gordon River, although the presence of trout is also a major influence. Aspects of the existing regulated flow regime which have affected the fish community structure are:

- Reduced fish migration opportunities have affected not only the Gordon River itself but also major tributaries;
- Domination of the upper reaches of the Middle Gordon River by brown trout, which appear to be less sensitive to a regulated flow regime than other species, and do not need to migrate to the sea to reproduce. Trout directly prey on native species as well as compete for common resources;
- Reversed seasonality of flows have affected spawning and migration cues;
- Rapid dewatering has lead to the potential for fish strandings;
- Reduced habitat quality and availability through sustained high flows and regular dewatering; and
- Reduced food supply due to lowered macroinvertebrate abundance, and reduced access by fish to the food supply during high flows.

3.5.4.6 Implications of Basslink

The predicted hydrological changes arising from Basslink operation of the power station are anticipated to result in several impacts to the Gordon River fish communities:

- Reduced habitat availability and quality in the Gordon River channel through more frequent flow fluctuations and dewatering;
- Reduced utilisation by fish of new habitats that may become available during the hydro-peaking cycle because of limited time periods to occupy these habitats;
- Increased potential for fish stranding in areas subject to dewatering as the frequency of such events is increased; and
- Reduction in invertebrate food supply for fish.

These effects are likely to result in a further, but possibly unmeasurable, reduction of an already depauperate fish fauna in the Middle Gordon River.

Basslink does, however, offer some positive benefits to the Gordon River fish communities. Notably, under Basslink there is an increased probability of native fish migration into the upstream reaches of the Middle Gordon River associated with the increased occurrence of short-duration and weekend shutdowns of the power station. Native fish populations of the Gordon River itself may increase temporarily due to increased fish migration opportunities, but it is unlikely that they will result in permanent native fish populations in the Gordon River itself due to habitat and food availability issues, as well as continued predation by trout. Increased upstream migration is likely to result in increased abundance and diversity of native fish populations in the tributary rivers and streams, and should help to replenish the older populations in these tributaries.

Appendix 8 shows that the effects of Basslink on the fish in the Gordon River valley are both positive and negative. The researchers conclude that the negative aspects relating to the Gordon River itself are outweighed by the potential for positive influences on the wider catchment through a return of greater fish migration opportunities.

3.5.4.7 Mitigation Options

A range of mitigation options were identified for the fish communities in the Middle Gordon River, and these included minimum environmental flows, flow ramping, scheduled shutdown events, a re-regulation dam, restocking of native fish and removal of brown trout. These options are not necessarily limited to mitigating the effects of Basslink alone.

Several of these options were discounted. The re-regulation dam was not recommended, as it would cause considerable loss of riverine habitat including tributary streams due to inundation, making the environmental impacts of the dam itself greater than the benefits. Native fish restocking was considered unlikely to be required given the increased migration opportunities, and it may be inconsistent with the WHA zoning objectives. Removal of brown trout from the Middle Gordon River, which would undoubtedly result in major benefits for the native fish populations, was considered impossible to achieve; even significantly reducing brown trout numbers would be prohibitively expensive, and further would disadvantage anglers in the tidal reaches of the Gordon River who target these fish.

Increased occurrence of short-duration and weekend shutdowns as are predicted to occur with Basslink, would mitigate against some of the existing effects of power station operations on fish migration.

Minimal environmental flows were recommended in Appendix 7 as being of benefit for the macroinvertebrate communities, and so indirectly would benefit fish which feed on the macroinvertebrates. However, to directly benefit fish these flows would have to be very low (less than 10 cumecs) to ensure adequate habitat availability for native species. A minimal environmental flow was not considered as mandatory for the mitigation of Basslink effects on fish, although if implemented with other aspects of the river ecosystem as a target, such a measure could provide some potential benefits for the fish.

Full ramping of the power station discharges was not recommended, as it would result in increased durations of high discharge which would prolong restrictions in habitat availability and would limit upstream migration opportunities for fish. A partial or stepped ramp-down was identified as potentially beneficial, as it could provide cues to the fish of dropping flows before full dewatering of habitats occurred, hence reducing the potential for stranding under Basslink.

3.5.4.8 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- the monitoring considerations of the individual researchers; and
- the Basslink-related options arising from those considerations.

3.5.4.8.1 Researchers' Monitoring Considerations

The monitoring suggestions made in Appendix 8 were for an electrofishing program, initially to establish the degree of inter-annual variation in fish stocks and, post-Basslink, to fully evaluate Basslink-related impacts. A comprehensive experimental design and data analysis protocol was outlined. It was suggested that the surveys undertaken as part of this study during 1999-2000 should comprise the first year of the monitoring program.

3.5.4.8.2 Basslink-related Monitoring Options

The monitoring program should follow a Before-After-Control-Impact (BACI) design consisting of three years pre-Basslink monitoring, followed by at least three years of monitoring after the implementation of Basslink. At least three tributary and three main channel sites should be surveyed in each of the five river zones as identified in Appendix 8. As well, a number of reference sites, both within the Gordon catchment and from other catchments, should be sampled simultaneously. These would include sites in the Franklin, Birch's Inlet, and Henty catchments.

Surveys should be undertaken by backpack electrofishing, with a target shocking time of 1200 seconds for each survey site per visit. All fishable habitats should be included in the site surveys to ensure a representative sample.

These surveys should be conducted twice a year, in December and April. At a minimum, all fish should be identified, counted and measured (fork length to the nearest mm). The resulting data should be analysed to assess changes with time in comparison to reference sites by conducting an ANOVA with time (year) and location (Gordon Zones vs reference rivers) as factors, and abundance (CPUE) of each species and overall diversity as test statistics.

The timing of sampling is designed to also coincide with other on-site field sampling activities (see Section 3.10).

3.5.5 Platypus and Native Water Rats

Two dominant terrestrial vertebrates depend on instream habitats and food production in western Tasmania, the platypus (*Ornithorhynchus anatinus*) and the native Australian water rat (*Hydromys chrysogaster*). Possible effects of Basslink were considered by Davies and Cook in Appendix 7 (Gordon River Macroinvertebrate and Aquatic Mammal Assessment).

There are no data on the abundance of either platypus or water rats in the Gordon River, but both species have been noted in the Gordon River by a range of observers. Platypus in particular were observed during the Basslink studies of the Gordon River in 1999 and 2000, both upstream and downstream of the Denison River. Detailed assessment of platypus habitat availability in the middle Gordon was conducted during this study as part of the modelling and assessment of habitat availability described in Appendix 7. Comparison were made in patterns of habitat availability for swimming and foraging under natural, present and Basslink flow regimes. These data were also included in the minimum flow risk assessment conducted to assess Basslink mitigation options.

Platypus rely on benthic macroinvertebrates (aquatic insects and crustaceans) as their major source of food, whereas water rats feed on macroinvertebrates and fish, as well as terrestrial invertebrates. There is considerable published information on many aspects of behaviour and life cycle needs of the platypus, but very little information on the water rat. Both species use burrows in river banks, with platypus burrows often sited at or just above the predominant water level.

Neither species is listed under the Tasmanian *Threatened Species Protection Act* 1995, and in Tasmania they are widespread and common.

The researchers propose that effects of the existing flow regime in the Gordon River on these two species may include:

- erosion and instability of soft (sand and peat) banks which may have limited available burrow sites;
- loss of overhanging riparian vegetation which is generally considered a pre-requisite for suitable burrow sites;
- high velocities at full power station discharge significantly reducing foraging habitat;
- rapidly fluctuating water levels disrupting access to burrows and possibly resulting in drowning in burrows; and
- reduction in diversity and abundance of benthic macroinvertebrate food, as described in Section 3.5.3 of this report.

The researchers conclude that the populations of platypus and water rats in the Middle Gordon River are likely to have been affected by the existing operations of the Gordon Power Station. No dedicated survey of the platypus or water rat populations of the Middle Gordon River has been undertaken. The major effect may be on the foraging success of females with young and on young emerging from burrow sites. Under existing conditions, the majority of the Middle Gordon River platypus population may in fact be resident in tributary streams, with foraging in the main river occurring only under favourable flow conditions (e.g. between large power station discharges).

The major gorges in the Middle Gordon River would represent barriers to passage of platypus during periods of high discharge, especially for non-resident individuals dispersing from tributaries. Increased occurrence of short-duration and weekend shutdowns under Basslink may in fact provide some benefit in terms of opportunities for dispersal past some of the major gorges.

Basslink may result in further indirect impacts on platypus and water rat populations by further reducing macroinvertebrate food supplies, and there may be some minor potential for increased mortality with increased frequency of rapid water level rises particularly for emerging young and dispersing juveniles. The researchers state that the latter possible impact is unlikely to be substantial in magnitude, and that there are no substantial differences in the suitability of habitat conditions for platypus and water rats in the Middle Gordon River between Basslink and existing operations.

Platypus monitoring and some dedicated studies of these fauna were suggested by the researchers for further consideration.

3.5.6 Terrestrial Fauna

Terrestrial fauna associated with the Gordon River was assessed by Griggs with her report provided in full as Appendix 9. This was essentially a desk-top study, and involved:

- examination of findings from the Lower Gordon River Scientific Survey in the mid-1970s;
- examination of the faunal species lists from the Department of Primary Industries, Water and Environment's (DPIWE's) threatened species database (GTSPOT);
- literature review; and
- documenting of researcher's observations during the 1999-2000 Basslink investigations on the Gordon River.

This study considered bird, mammal, reptile, and invertebrate species in the Gordon River.

Eleven species of birds have been recorded on or near the Gordon River. There has been no dedicated assessment of the influence of regulated flow on bird species in the Gordon River, or for that matter in any regulated river in Tasmania. The low diversity of species found near the river is believed to be due to the generally steep and vegetated banks of the Gordon River, and the very few flat open banks suitable as habitat for wading birds. Where flat open banks exist, sudden changes in river depth even under unregulated flow conditions, as recorded by the Lower Gordon Scientific Studies, limit the availability of this habitat to wading birds. GTSPOT lists three species of birds in the Gordon catchment as threatened: the Wedge-tailed eagle, the Swift Parrot and the Grey Goshawk. Of these, only the Grey Goshawk has habitat requirements which are dependent on a wetland ecosystem, including fish as a source of food.

Seventeen terrestrial mammal species were recorded in the Lower Gordon Scientific Survey report. GTSPOT records the native Spotted-tail Quoll, Ringtail Possum, Long-tailed Mouse, Pademelon, Brushtail Possum, and the introduced cat and Black Rat as occurring adjacent to the Gordon River near Sir John Falls and downstream of here, which is downstream of the study area for the Basslink studies (the Middle Gordon River). Only the native Tasmanian Devil and introduced cat are recorded in GTSPOT near the Gordon Dam. Both of these species were observed in the Middle Gordon River during the Basslink investigations.

The only reptile recorded by GTSPOT for the Gordon River is the Tasmanian Tree Skink, located near the Gordon Dam and also in the Lower Gordon River (downstream of the Franklin River). This species is widely distributed across the State, as well as on the offshore islands.

Thirty-nine orders of invertebrates were identified in the Lower Gordon Scientific Studies. The number of species was estimated to be 4,000-5,000. Notable identifications were the Little Six-Eyed Spider listed as rare under the *Threatened Species Protection Act* 1995, and the Velvet Worm recorded on the GTSPOT database as located in the Gordon River valley.

A number of the terrestrial fauna species are significant in terms of World Heritage Values, as discussed further in Section 3.8 of this report.

There are no significant Basslink issues for terrestrial fauna identified in Appendix 9. Those that inhabit the banks of the Gordon River would have adapted to the regulated flow over the preceding 25 years, and the Basslink changes are not considered significant enough to further disturb these fauna. There may potentially be some minor secondary impacts in the Gordon River related to food sources such as fish, which would at most cause some minor changes in feeding patterns and can not be seen to cause any impacts to populations as a whole.

3.5.7 Cave Flora and Fauna

3.5.7.1 Background

Cave flora and fauna were investigated in Bill Neilson Cave and in Kayak Kavern. The full results of these investigations are presented in Appendix 10.

Caves are usually divided into distinct environmental zones, and distinct types of cave fauna are attached to these. These zones are described in order of increasing distance into the cave:

- The **entrance zone** is usually the mouth of the cave, where surface and underground environments meet and environmental conditions can be variable. Cave flora is limited by light penetration, and so is usually restricted to the entrance zone of caves. Cave fauna inhabiting the entrance zone includes the troglophiles (live and reproduce in caves but are not confined to them) and the trogloxenes (regularly inhabit caves but must return to surface for part of lifecycle such as feeding or breeding).

- The **twilight zone** is where light steadily diminishes, but environmental conditions including temperature remain variable. Troglophiles are found in the twilight zone. Trogloxenes are usually in or near the entrance zone, but may extend deeper to roost or lay eggs.
- The **transition zone** is where darkness is complete, but external environmental conditions still have some influence, mostly via stream or air currents. Both trogloxenes and troglophiles may be found in the transition zone but their numbers are much lower, as it is further away from the surface for trogloxenes and (consequently) less productive foodwise for troglophiles.
- The **deep cave/troglic region** is usually a long way from the entrance, environmental conditions (notably temperature) are relatively stable, humidity is high, and evaporation is negligible. Species found in this region are known as troglobites, and are strictly adapted to subterranean habitats and can not survive outside of them. Troglobites often show unique and unusual adaptations to their environment, and troglobite species are often restricted to the karst body in which they are found.

An additional category of cave fauna is termed “accidentals”. These are surface animals which wander, fall or are washed into caves, but will not survive for long.

Cave ecosystems are directly dependant on surface events, despite their apparent isolation. Food is provided by stream borne detritus, entrance zone vegetation and infall, trogloxene and troglophile movement and population cycles, accessibility of substrate, and rootlet ingrowth. External influences on ground and surface water as well as environmental conditions can all influence cave ecosystems.

3.5.7.2 Methods

Methods employed were a search for presently-available information, and field investigations over five non-consecutive days between July and September 2000. Field investigations were concentrated on Bill Neilson Cave, and also encompassed a brief assessment of Kayak Kavern. Kayak Kavern is essentially a large overhang and is occupied only by entrance zone fauna. All further discussion relates to Bill Neilson Cave.

Restrictions in access to the cave meant that cave faunal surveys were indicative rather than comprehensive, and insufficient time was available to ensure the capture or trapping of rarer cave species (which often are small, cryptic, sparse and inaccessible). Despite the restrictions in access and available time, the faunal surveys were rigorous and in line with recommended approaches.

Assessments in Bill Neilson Cave encompassed aquatic fauna, terrestrial fauna in the stream passage and entrances, terrestrial fauna on the siltbanks, and cave entrance and daylight hole flora. Identifications were a mix of in-field identifications and collections of both live and preserved species for laboratory identification.

3.5.7.3 Findings

Bill Neilson Cave is characterised by numerous entrance and daylight holes along its length. Most of the cave fauna consists of surface, troglophilic and trogloxenic species, and there is little development of troglobitic fauna for much of the cave. Species lists were compiled for cave fauna and flora. Findings are discussed under the headings flora, stream fauna and terrestrial fauna.

3.5.7.3.1 Cave Flora

Cave flora are found only in the entrance zones and daylight holes, and mostly consists of species which are common in the surrounding forest. Cave flora surveys produced only one species of significance: the bryophyte *Thuidium laeviusculum*, which has only been found on one other occasion since 1912 and has not previously been found on the west coast. Lichens and bryophytes represent a very rich and specialised field separate to other flora, and may benefit from specialist collections and surveys in future. However, most of the areas that will be affected by water level fluctuations in Bill Neilson Cave are covered by thick silt with no vegetation. *T. laeviusculum* was only collected from a daylight hole well above the area that will be affected by Basslink operations. Erosional and depositional issues are potentially the greatest impact to the cave flora.

3.5.7.3.2 Stream Fauna

Because of the number of the daylight holes, the stream fauna in the Bill Neilson Cave is predominantly of surface origin. The species present would therefore be far more robust to water level fluctuations arising from power station operations. Some non-listed species of conservation significance were present (such as the crayfish, *Astacopsis tricornis*), but these are widely spread surface species and so are not likely to be affected by variations to water patterns in the Bill Neilson Cave.

3.5.7.3.3 Terrestrial Fauna

Terrestrial fauna can be further sub-divided into streamway and siltbank fauna.

The non-surface fauna along the streamway was found to be predominantly the Hickman's cave spider, cave crickets and glow worms. These are a mixture of troglophiles and trogloxenes. Species found in this cave are common throughout the cave and the surrounding forest.

Siltbank fauna is more representative of a deeper cave fauna. These areas are out of the direct influence of power station water patterns, but can be influenced by changes to humidity, temperature and air flow which can be caused by flow alterations. However the multitude of daylight entrances in the Bill Neilson Cave would significantly reduce the implications of water management changes.

As with the flora, erosional and depositional changes that undermine or swamp sediment and siltbanks potentially represent the greatest issue for the terrestrial fauna.

3.5.7.3.4 Listed Species

Under the *Threatened Species Protection Act* 1995, the potential impacts of Basslink operations need to be addressed for any listed flora and fauna found within the cave. None of the species collected or observed within the cave are currently listed under the *Threatened Species Protection Act* 1995. However, some of these species may qualify for listing once they are known in greater detail, and there is the potential that listed species (or other candidates for listing) may also be present in the cave that were not collected or observed in the time available.

In general, as discussed in Appendix 10, the potential impacts of Basslink are not likely to be acute or species-specific, but instead are likely to be limited mainly to erosional and depositional issues along the sediment banks and the base of the siltbank. (which may undermine their habitat).

3.5.7.4 Management Implications and Further Monitoring

Because of the multitude of daylight holes, Bill Neilson Cave appears to show little development of troglobitic fauna in comparison to other caves. Any troglobitic species present are likely to be beyond the influence of stream fluctuations. The prevailing regulated flow conditions in the Gordon River over the past 30 years means that cave flora and fauna have most likely adjusted to this flow regime. The main potential management issues are therefore new hydrological changes which affect the stability of the siltbanks.

The researchers proposed that any further monitoring repeat key elements of the survey work conducted for this assessment. Proposed monitoring activities include collection and census of both the flora and fauna communities in specific habitats and locations (aquatic, streamway-entrance and siltbank) within the cave. Sampling would provide species lists at these points and throughout the cave, and the abundance of species within communities at these census points for comparison to the preliminary baseline data collected within this study. Because there are no major projected impacts on cave biota arising from Basslink operation of the Gordon Power Station, monitoring of cave biota is not included in the proposed Basslink Monitoring Program. However, should karst geomorphology monitoring show significant changes to the sediment and silt banks or other habitats within Bill Neilson cave, further cave biota assessments would then be undertaken.

3.6 Environmental Assessment of Estuarine Impacts – Meromictic Lakes

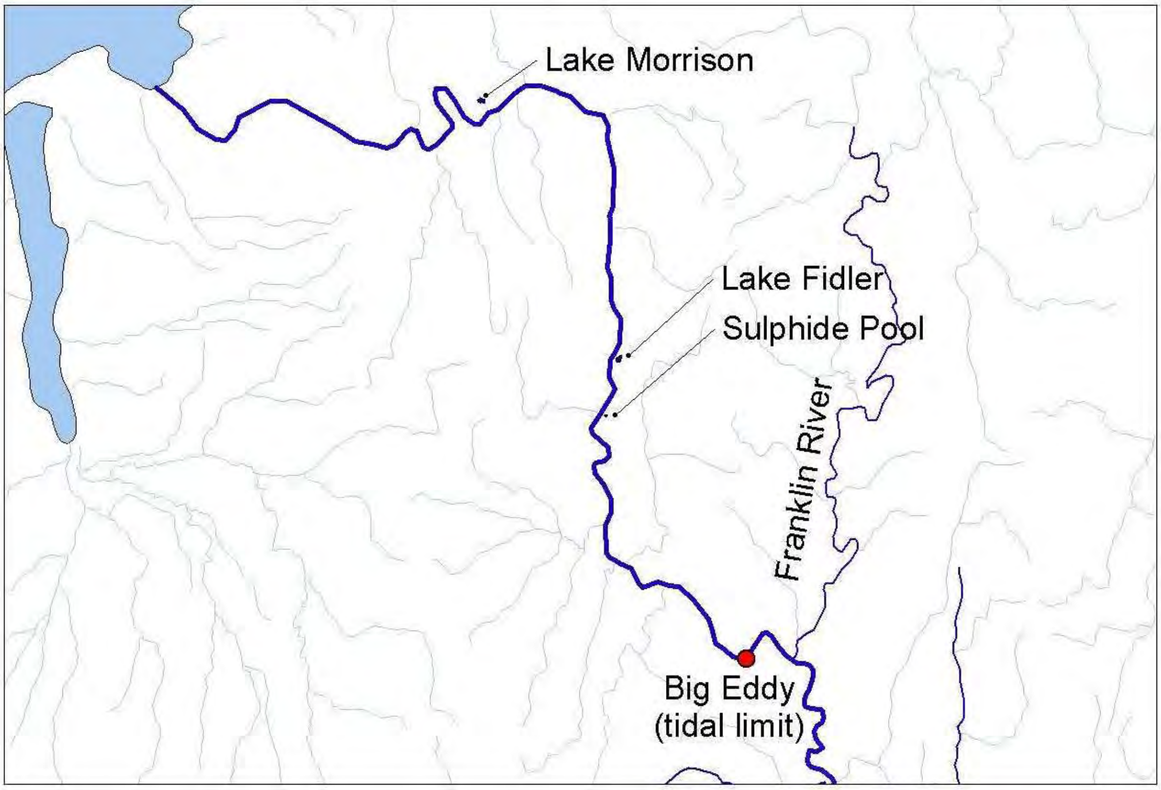
The Lower Gordon River meromictic lakes were assessed by Tyler, Terry and Howland, with the full results presented in Appendix 11.

3.6.1 Background to the Lower Gordon Meromictic Lakes

Meromictic lakes in the Lower Gordon River were assessed as part of the Basslink investigations on the Gordon River. ‘Meromictic’ refers to lakes that are permanently stratified by virtue of denser, saltier water in the bottom strata, and mixing of surface waters does not affect bottom waters which are separated by a ‘chemocline’.

There are three meromictic lakes in the Lower Gordon River, known as Sulphide Pool, Lake Fidler and Lake Morrison, shown on Map 3.10. They came to the notice of the scientific community in the 1970s through the HEC’s “Lower Gordon River Scientific Survey”. There are less than 150 meromictic lakes known in the world, and only four others besides those in the Lower Gordon River occur in Australia. The three Lower Gordon meromictic lakes are among the important natural values for which the area was proclaimed a World Heritage Area.

The ‘monimolimnion’ is the name given to the lower stratum of meromictic lakes. This layer has unique characteristics including being devoid of oxygen, charged with hydrogen sulphide and other compounds, and populated by microbes with Precambrian attributes. Meromictic lakes display very fine zonations of chemical and biological features in the chemocline, the zone which divides the fresh surface water from the saline bottom water.



Map 3.10 Meromictic lakes and Big Eddy, the tidal limit.

3.6.2 Saline Recharge Mechanism

With time, meromictic lakes devolve towards 'holomixis' typified by uniform water quality characteristics and mixing throughout, unless there is periodic top up with denser saline waters. In the Lower Gordon River, this is believed to occur when the estuarine salt wedge advances upstream as far as 38 km from the river mouth. The mechanisms for the actual recharge are complex but are believed to be understood in principle, and require the congruence of three sets of circumstances:

Circumstance 1:	The undercutting salt wedge in the Gordon River must push upstream some distance beyond the lake. This is favoured by high tides, strong north-westerly winds, and, particularly, low flow in the river. The salt wedge in the Gordon River has been observed on numerous occasions as far upstream as Big Eddy (see Map 3.10), well upstream of the meromictic lakes.
Circumstance 2:	A spate of fresh water down the Gordon River, coinciding with the salt wedge well upstream of the lakes, must mix with the saline wedge to cause salinity of the surface water of the river to values well in excess of surface waters of the lakes.
Circumstance 3:	The spate of fresh water down the Gordon River must also raise river water levels sufficiently for brackish water to flow into the lakes via their respective connecting creeks.

The flow of salty water into Lake Fidler has been recorded by Hodgson and Tyler (1996), and there is mineralogical evidence in the lake sediments of Lake Fidler attesting to regular intrusions of salt water over several thousand years. The three lakes have shown a decline in meromixis since the discovery of this feature in 1977, and by 1983 Lake Morrison and Sulphide Pool had become holomictic. Measurements of the chemocline have only been taken post-flow regulation, so trends in chemocline stability of the Gordon meromictic lakes under unregulated flow conditions are not documented. Lake

Morrison and Sulphide Pool are shallower than Lake Fidler, so wind-induced devolution can play a larger role in these lakes. Lake Morrison is known to have alternated since 1977 between holomixis and meromixis, and Sulphide Pool may do the same.

The ongoing viability of the meromixis of these three lakes is closely linked to probabilities of appropriate flows, and their timing, coming down the Gordon River. There are other theories for a saline recharge mechanism of the meromictic lakes, for example via groundwater movement, which are discussed but discounted in Appendix 11.

3.6.3 Present Status

The study undertaken by Tyler *et al*. and reported on in Appendix 11 involved investigations into the present state of meromixis in the lakes, and the dynamics of penetration of the salt wedge. Vertical profiles of selected physicochemical parameters in the water columns of Lake Morrison and Lake Fidler were measured *in situ*. Vertical profiles of salinity and temperature along relevant stretches of the river were determined to assess the behaviour of the salt wedge. Data loggers continuously recorded temperature, salinity, and current direction and velocities in the channel between the Gordon River and Lake Fidler. Samples of key microbiological species were examined.

The investigations of Lake Fidler as part of this study show that the salinity of the monimolimnion, which had remained constantly between 3,500 and 4,000 µS/cm between 1977 and 1994, is now only half of its previous value. Microbes from strata which have shown a stable array in the past are now absent or occupy different positions, pointing to disturbance of the chemocline/redoxcline.

3.6.4 Modelling of Movement of the Gordon River Salt Wedge

Tyler *et al*. set out to model the optimum conditions for promoting brackish water inflow into Lake Fidler. The researchers calibrated a numerical model which had been developed for Macquarie Harbour (Terry 1998) to analyse conditions in the Lower Gordon River. Field data were collected during the Basslink investigations in 2000, measuring the movement of the salt wedge under low Gordon River flow, and utilised for model calibration.

Lake Fidler, located 26 km upstream of Macquarie Harbour, was the focus of the modelling assessment. Lake Fidler has the most stable meromixis of the three lakes, it is deeper than the other two lakes, and it is located closer to the river channel. Therefore it was thought to have the highest chance of recharge events, and was the most likely of the meromictic lakes to yield imortant data during experimental shutdowns of the Gordon Power Station for the Basslink investigations.

Salt water is denser than freshwater. Because of density differences and water pressure forces (predominantly tidal), a salt wedge can migrate upstream despite a surface freshwater layer still flowing downstream, as long as the freshwater flow is small enough. The salt wedge position is controlled by river flow, as high freshwater river flows will tend to drive the salt wedge out.

Figure 3.17 shows the model output for time required for the salt wedge to travel upstream to Lake Fidler (26 km) and beyond (28 km, 30 km) under a range of flow conditions in the Gordon River. The wedge needs to travel beyond Lake Fidler for a successful recharge event to occur. A target distance for the salt wedge migration of 28 km upstream of the Gordon River mouth (2 km upstream of Lake Fidler) was adopted for the purposes of the modelling study. Figure 3.17 indicates that if lower Gordon flows (Gordon below Franklin River) are approximately 31 m^3/s without the power station discharge, the power station would need to be shutdown for a week to set up the ‘Circumstance 1’ conditions (see Section 3.6.2). If lower Gordon flows are approximately 50 m^3/s without the power station discharge, the power station would need to be shutdown for two weeks to set up the ‘Circumstance 1’ conditions.

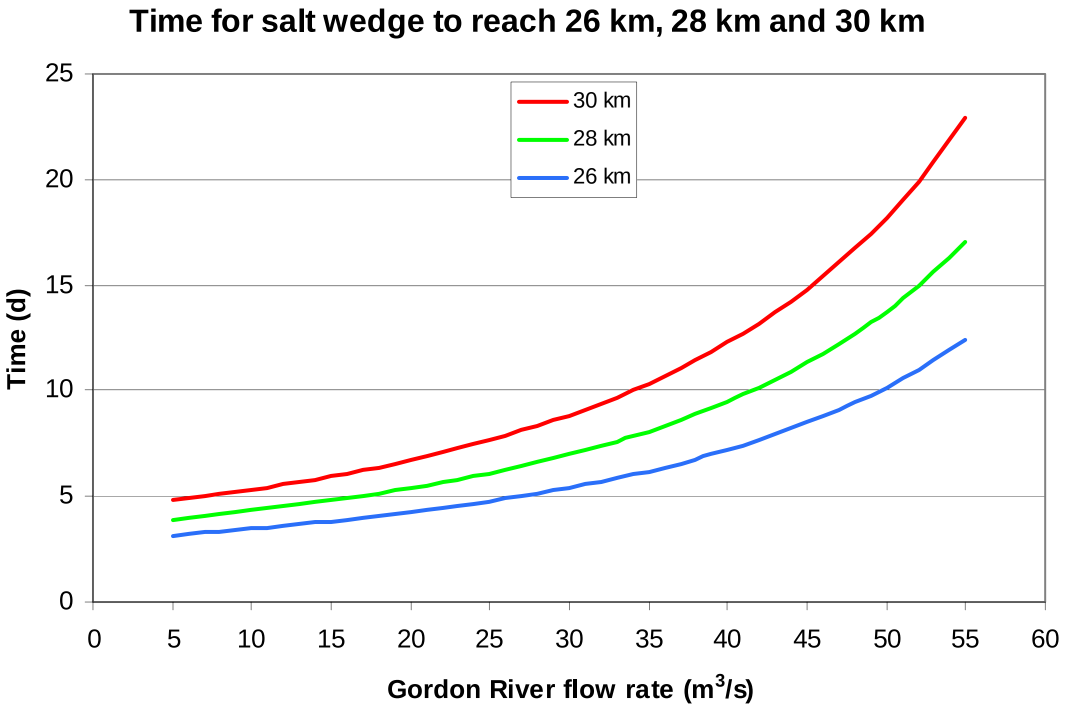


Figure 3.17 Time for salt wedge to move up the Gordon River to Lake Fidler (26 km), 2 km upstream (28 km) and 4 km upstream (30 km)

A detailed analysis of flows in the Lower Gordon River from 1970 to present is presented in Appendix 11. In this analysis, all low flow periods suitable for salt-wedge migration (e.g. 7 days at 31 cumecs, 14 days at 50 cumecs) were identified, and the circumstances leading to occurrence of these low flow periods examined. Four years were shown to have extended periods of low flow suitable for salt-wedge migration: 1981, 1988, 1993 and 1996. An examination of power station operations over the same period has shown that these same four time periods are associated with major power station shutdowns for maintenance or capital works purposes. These shutdowns were not for routine maintenance purposes, but rather for unusual maintenance or installation requirements (e.g. 1988 was when the third generator was installed). Since 1996, no opportunities for saline recharge have been identified from the hydrological record.

Due largely to the increasing electricity demand and the need to ensure reliability of electricity supply for Tasmania, maintenance practices at the Gordon Power Station and associated infrastructure are heavily constrained under existing operations in order to minimise downtime at critical times of the year. The maintenance practices associated with long shutdowns since 1996, for instance, are highly compressed, and it is unlikely that Basslink will significantly change this. Hence it is unlikely that the probability or the timing of major shutdowns will change as a result of Basslink. Consequently, the meromictic lakes which are reliant on such shutdowns for the possibility of natural saline recharge, are unlikely to be further affected by Basslink.

Further analysis of measures which could improve the meromictic condition of the lower Gordon meromictic lakes will be undertaken as part of Hydro Tasmania's Water Management Review for the Gordon catchment. Water Management Reviews are described in Section 1.3.2 of this report. Options to be investigated include the provision of Gordon Power Station shutdowns during low flow periods, as well as interventionist strategies such as the pumping of saline water directly to the lakes.

3.7 Environmental Assessment of Socio-Economic Impacts

3.7.1 Scope of this Section

This section examines socio-economic aspects of the Gordon River in relation to present status and potential Basslink changes. Specific aspects examined are the cultural heritage (Section 3.7.2), visual amenity (Section 3.7.3), public use and public safety (Section 3.7.4), and industries affected and economic impacts (Section 3.7.5).

3.7.2 Cultural Heritage

A cultural heritage survey was undertaken of the Middle Gordon River between November 1999 and March 2000 by McConnell, Stanton and Scripps. Their full report is provided as Appendix 12.

The researchers undertook their study in two parts, the first being a desktop review of the history and heritage of the Middle Gordon River, and the second being a field survey. The desktop survey helped formulate the field survey design, which focussed on areas potentially at risk from Basslink, as well as identify known or potential cultural heritage values. Field investigations were concentrated on all flat or nearly flat land along the Gordon River margin from the tailrace down to the Denison River confluence, and between the Olga River confluence and Moores Landing. Aerial inspections of hydro investigation camps were also undertaken. The study also involved consultation with stakeholders, in particular the Aboriginal community through the Tasmanian Aboriginal Land Council (TALC), and the Cultural Heritage Branch of DPIWE.

The cultural heritage study assessed Aboriginal and European cultural heritage values. Southwest Tasmania, including the Gordon River corridor, is likely to have been used extensively in the past by Aboriginal people at least as far back as 36,000 years ago, and is known to have been used since the early 1800s by non-Aboriginal people. Previous research and assessment of the cultural heritage of the Gordon River is limited to two reconnaissance type surveys for Aboriginal sites in the early to mid-1980s, two reviews of historic activities in the broader region which incorporates the Gordon River (1981 and 1994), and documentation of historic sites in 1990 upstream to Lawn Creek below the Olga River confluence.

All Aboriginal sites are protected under the Tasmanian *Aboriginal Relics Act* 1975, and registered historical cultural heritage sites are protected through the Tasmanian *Historical Cultural Heritage Act* 1995. Any sites of historic significance within national parks or other reserved land are protected by the *National Parks and Wildlife Act* 1970.

The Middle Gordon River contains only four known Aboriginal sites – two potentially occupied rock shelters, one artefact scatter and one isolated artefact find. All of these were located by previous studies. Three of these are situated relatively high in the landscape, and the fourth is located in the Franklin River valley, so all are considered out of the zone of influence of the Gordon Power Station. None of the four known Aboriginal sites are listed on the Register of the National Estate or other relevant registers, but Aboriginal sites in the region as a whole have acknowledged World Heritage value. The researchers have also identified broader Aboriginal values in the Middle Gordon River, primarily landscape values such as plant, animal and geological resources, and probable major routes of movement. These however are large scale and widespread values not considered to be affected by the proposed development.

Forty-nine sites of European cultural heritage have been identified along the banks of the Gordon River downstream of the power station. The sites have resulted from Huon pining activities, hydro-electric development investigations, early exploration and track cutting, and tourism. Twenty of these sites are upstream of the Franklin River confluence. None of the forty-nine sites are listed on the

Tasmanian Heritage Register or the Register of the National Estate, and there are no acknowledged World Heritage values related to historic heritage in the Gordon River corridor. The Huon pining sites, which are identified by areas of modified vegetation, hut foundations, cut trees and/or tracks, and the hydro sites which consist of investigation camps, are mostly located close to the edge of the Gordon River. Because of the absence of pre-dam development studies, it is difficult to assess existing effects of power station operations on these sites. There is, however, no definitive evidence of impact at specific sites.

Potential impacts to the identified cultural heritage sites arising from Basslink are limited to bank erosion. It is assumed that heritage values within 10-20 m of the present river bank are most at risk, with the degree of risk diminishing with distance away from the river. There is no potential for any of the known Aboriginal sites to be affected by the proposed changes to the Gordon River flow regime. Seven of the known historical sites in the Middle Gordon River occur within 50 m of the river bank. Three of these are within 20 m of the river bank between the tailrace and the Splits, and are all minor pining related sites with very limited physical evidence.

Because of the evidence of an extremely long term Aboriginal presence in the Gordon River catchment area (e.g. painted caves and rock shelters in limestone tributary catchments), it can not be concluded that there are no additional sites in the Middle Gordon River, as locating sites is difficult given the very poor ground surface visibility. However, the potential for additional sites in the Middle Gordon River is considered by the researchers to be very low in the areas identified in the fluvial geomorphology study (Appendix 4) as being likely to be affected by Basslink changes to power station operations. There is some potential for further sites of European heritage to be located, mainly pining camps and depots, but these are also unlikely to be located in the area of impact from Basslink operation of the power station.

The researchers identified no management issues or required mitigation options for the Middle Gordon River in relation to cultural heritage. They recommend ongoing checks for sites particularly in combination with assessments of changes in riverbank morphology. Additional site investigation would ideally be conducted on an opportunistic basis when there may be better ground surface visibility, for example after fire.

3.7.3 Visual Amenity

The Middle Gordon River is not a commonly viewed part of Tasmania, because of its remoteness, difficulties of access, and adverse weather conditions. People likely to obtain views of the Middle Gordon River are those on scenic flights, recreational fishers and boaters in the lower reaches of the Middle Gordon River, and scientific researchers. Effects of existing power station operations which are visually apparent are the erosion processes and loss of vegetation on the river banks under low flow conditions (power station off), particularly upstream of the Splits. These effects are most apparent when the viewer is actively looking for them, as virtually no one was aware of them prior to the environmental investigations undertaken as part of this Basslink project. The changes are also most apparent when directly compared against the riverbanks in an unregulated tributary such as the Denison or Franklin River, where the occurrence of mixed vegetation species including mosses and ferns are found right down to the low water mark. Photo 3.1 shows a riverbank in the Franklin River with vegetation apparent to the low water mark, fallen trees evident, and an undercut feature which occurred due to natural processes and is naturally revegetating.

Photo 3.1 Riverbank in the Franklin River, with mosses and ferns apparent right down to the low water mark.

The main visual perspectives on the riverine corridor of the Middle Gordon River are by air or from mid-river channel. The viewfields from these perspectives vary depending on the altitude of the flight, and whether or not the power station is discharging. These different perspectives are discussed in turn.

<u>From the Air at High Altitude</u>

From the air at high altitude, the river corridor is viewed within the broader wilderness setting of dense forest and highly variable terrain. At high altitude, instream islands are visible at all power station flows, but instream cobble bars are only visible at low flows with the power station off. Views of the riverbanks are very limited from high altitude because of overhanging trees, with the exception of areas of landslip which are mostly found within the zones immediately downstream of the power station. The comparison of power station off aerial photographs undertaken as part of the Gordon River Fluvial Geomorphology Assessment (Appendix 4) showed details as clear as individual fallen logs, but because of the overhanging vegetation near the river banks it is very difficult to pick out occurrences of erosion other than by a very localised loss of vegetation. The viewers’ focus at high altitude tends to be on the broader region, with a closing in of focus on the spectacular gorge sections and unusual features such as the Sprent River delta. Photo 3.2 shows a high-altitude view of the Middle Gordon River.

Photo 3.2 High aerial view of Zone 2, looking downstream

<u>From the Air at Low Altitude</u>

From the air at low altitude, views of the riverbanks under the overhanging trees are possible, and closer views can be obtained of the instream islands. When the power station is discharging, the viewer sees virtually no impact of power station operations, other than the landslips which occur in the zones immediately downstream of the power station, and possibly the channel widening that occurs at the mouth of the Albert River. Photo 3.3 shows a low aerial view of the Middle Gordon River with the power station on, showing the dense vegetation right to the high water mark.

Instream cobble bars are only visible when the power station is completely shutdown (Photo 3.4). Views of the active erosional processes on the banks, and the loss of vegetation below the Plimsoll line, can be seen from low-altitude flights when the power station is shutdown, and to a lesser degree when the power station is utilising one or two generators. The erosional processes are best seen upstream of the Splits when the power station is shutdown (Photo 3.5), where there is a greater range in water level variation leading to a broader de-vegetated zone.

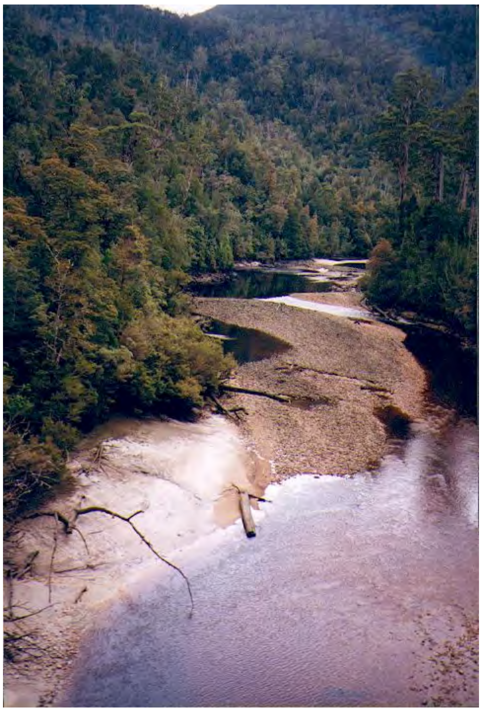


Photo 3.3 Low aerial view of Middle Gordon River under high flow conditions

Photo 3.4 Low aerial photo upstream Abel Gorge showing exposed cobble bars with power station off.

Photo 3.5 Low aerial view of Zone 2 upstream of the Splits

From Mid-Channel

The clearest views of power station influences on the Middle Gordon River are seen when the power station is completely shutdown, and one is positioned in a boat in the river or standing on an instream cobble bar or riverbank. The changes to riverbank condition are most clearly seen upstream of the Splits, such as shown in Photo 3.6, especially when one is positioned so that they can look up under the overhanging vegetation. The occurrences of recent landslip are the clearest visual impacts (Photo 3.7), but this visual impact appears to diminish within a matter of years as the dense vegetation covers over the area as is shown by the Basslink visualisations later in this section. Photo 3.8 and Photo 3.9 show that the degree of visual impact from a river level view is relatively diminished downstream of the Denison River.

Photo 3.6 Ground level view of highly active alluvial bank between Abel Gorge and the Splits under low water conditions

Photo 3.7 Ground level view of recent landslip between Abel Gorge and the Splits under low water conditions

Photo 3.8 Typical river level view in the Middle Gordon River downstream of the Denison River, under low flow conditions

Photo 3.9 Typical river level view of an alluvial bank in the Middle Gordon River upstream of the Franklin River, under low flow conditions

Because there is some potential for further geomorphic adjustments and vegetation changes on the Middle Gordon riverbanks under a Basslink operating regime of the Gordon Power Station, particularly upstream of the Splits, the Gordon River Fluvial Geomorphology Assessment (Appendix 4) included an assessment of potential visual changes to the banks of the Middle Gordon River. For this assessment, four images of the Geomorphology Zone 2 (between Abel Gorge and the Splits) were selected, and the postulated changes under Basslink were applied to the photos using photo enhancement techniques. The following five paragraphs and photos are taken from Appendix 4.

Three images reflecting a range of 'typical' bank conditions were chosen along with one image showing an 'extreme' series of landslips part of which occurred during the study period. All chosen shots depict low water level, because during high water, the bank features are not visible. Changes applied to the photos included:

- Increasing the height of the Plimsoll line through loss of vegetation;
- Decreasing banks slope reflecting potential seepage and sub-aerial erosion and;

- Reducing the amount of tea tree on banks; and
- Increasing the deposition of LWD on banks due to tree fall.

Paired photos showing the 'present' photo and the potential theorised 'Basslink' changes are shown in Photos 3.11 to 3.17. The Basslink impressions for the first three 'typical' images are intended to show banks in equivalent stages of bank adjustment to the flow regime as the present images. Intermediate stages that are likely to be characterised by high erosion activity, including seepage erosion and tree fall are not shown, but would be expected to occur. The Basslink image in the final set of photos shows a possible 'stable' endpoint for slips and tree fall occurring in steep alluvial banks. The actual bank shown in the photo contains a several metre thick section of cobbles, and it is possible that the 'endpoint' of these slips may actual have steeper vertical faces than depicted.

The first image (Photo 3.10 and 3.11) is an aerial shot of a reach of the Gordon River in Zone 2. The Plimsoll line is higher under Basslink, and there is increased tree fall, but overall, aerial views of the river are not expected to alter markedly under Basslink.

Photo 3.10 and 3.11 Present (left) and projected Basslink (right) views of Zone 2

The next two sets of images (Photo 3.12 to 3.15) show shallowly sloping and steeply sloping banks, respectively. The steeply sloping banks are upstream of the Splits, where water level fluctuations are greatest in the Middle Gordon River. In both sets of images, the Basslink visualisations show an increase in the Plimsoll line, and devegetated bank toes. The shallowly sloping banks show a loss of tea tree. The steeply sloping bank would be expected to undergo significant additional tree fall under Basslink as the Plimsoll line increases in height (due to longer duration high flow events).

Photo 3.12 and 3.13 Present (left) and projected Basslink (right) views of a shallow-sloping bank

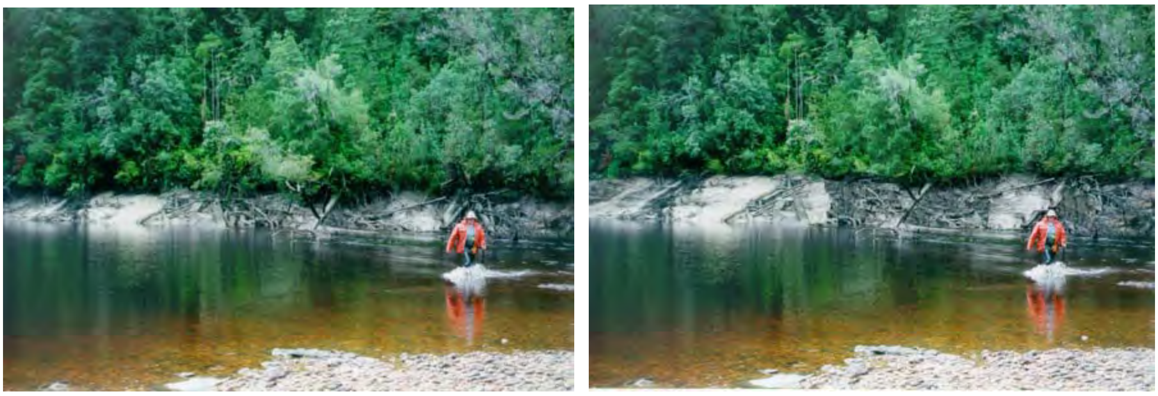


Photo 3.14 and 3.15 Present (left) and projected Basslink (right) views of a steeply-sloping bank

The final set of images (Photo 3.16 and Photo 3.17) shows a series of landslips, several of which occurred during the study period. The Basslink visualisation shows a decrease in bank slope, the accumulation of woody debris on the lower bank face and toe, and revegetation of the slips above high water level by ferns. As mentioned before, the presence of cobbles in these banks may result in steeper vertical faces with less vegetation than shown here. However, the depicted ‘endpoint’ is applicable to scarps created in steep riverbanks due to tree fall.

Photo 3.16 Present appearance of landslips in zone 2

Photo 3.17 Projected Basslink appearance of landslips in zone 2

These photos are idealised, and should not be considered to be exact projections, but rather indications of changes anticipated to occur under Basslink based on the present understanding of bank erosion in the river. The photos show the types and magnitude of changes anticipated to occur over a long period (decades), recognising that a period of active adjustment is likely to occur following the implementation of a new flow regime.

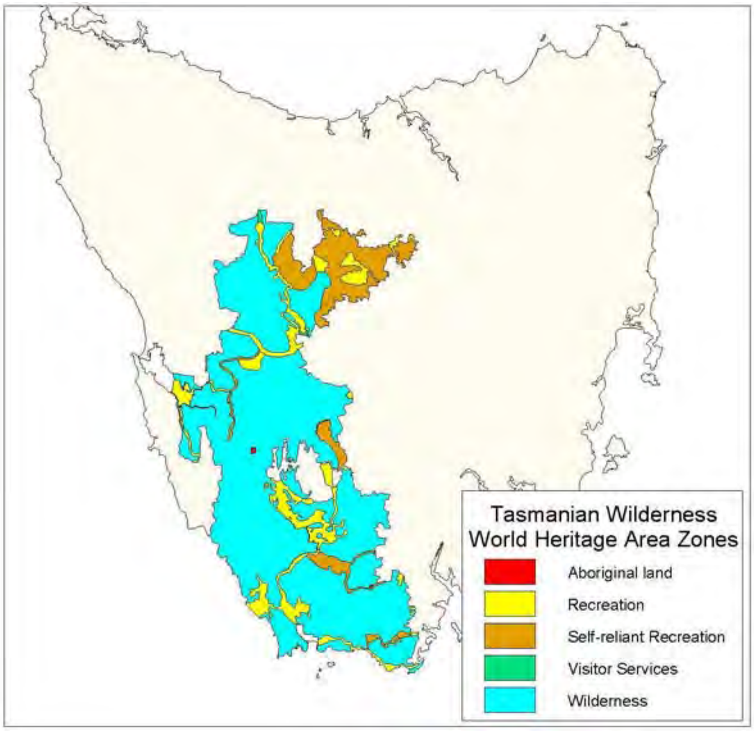
3.7.4 Public Use and Public Safety

Public use of the Gordon River downstream of the Gordon Dam was assessed by Kriwoken, and is reported on in full in Appendix 13. This report was based on a desk-top exercise involving reviews of data from Tourism Tasmania's 'Tasmania Visitor Survey', the Tasmanian Parks and Wildlife Service (PWS) log books for the TWWHA and the Franklin River, and on personal interviews with key managers, operators and users of the Gordon River.

The TWWHA is divided into zones under a 1999 Management Plan, with each zone having specific uses and objectives. These zones follow a spectrum from 'increasing naturalness and remoteness' to a focus on 'increasing infrastructure, development, recreation and tourism'. They are shown on Map 3.11 and comprise the following:

- Wilderness zone – provides for limited recreation with no new facilities or mechanised access, characterised by high wilderness quality.
- Self-reliant recreation zone – reserves areas of high wilderness quality and/or environmental sensitivity, for example the Franklin River.
- Recreation zones – provide a range of recreational experiences and can include high levels of activity and a range of associated infrastructure, for example, the Lower Gordon River downstream of Sir John Falls.
- Visitor Services zones and sites – areas where facilities are concentrated and most visitors will experience the WHA, for example at Sir John Falls and Heritage Landing.

The majority of the TWWHA is zoned wilderness, and the Middle Gordon River corridor is within a wilderness zone. The wilderness zone objectives are to allow natural processes to operate with minimal interference, retain a challenging unmodified natural setting that suitably experienced and equipped people can visit for wilderness recreation and scientific purposes, and use wilderness as a primary means of managing WHA and associated values.



Map 3.11 Tasmanian Wilderness World Heritage Area.

The vast bulk of public use of the Gordon River is located in the Lower Gordon River below the Franklin River. Cruise boats are one of the largest users of this part of the river, but their routes do not extend upstream of the Lower Gordon River.

Bushwalking in the Lower and Middle Gordon River is extremely difficult. The Middle Gordon River has no maintained tracks and the forest is largely impenetrable.

The Franklin and Lower Gordon River receive numerous rafters, kayakers and boaters, but boat access to the Gordon River upstream of the Franklin River is relatively rare and in many places very dangerous. Rafters and kayakers have been known to paddle the Middle Gordon River, accessing it either downstream of the Gordon Dam (with the power station shutdown), or via the Jane or Denison Rivers. Access via the Jane or Denison rivers involves pulling or carrying boats through the bush, and would only be suitable for extremely experienced bushwalkers/paddlers with excellent navigation and wilderness survival skills.

Recreational fishers visit the Gordon River to catch trout, concentrating their efforts in the Lower Gordon River but also venturing as far upstream as the Splits. The vast majority remain downstream of the Sprent River delta.

Commercial float planes operate out of Strahan, and run daily trips from Strahan to Sir John Falls. They fly over the Lower and Middle Gordon River, but no data were able to be obtained on routes or frequency.

Finally, the last category of public use is investigators/researchers for specific developments. The Gordon River was the focus of considerable investigative and research activity in the early 1960s and 1970s related to dam investigations. Most recently the Middle Gordon River has experienced 14 months (October 1999 – December 2000) of activity related to scientific research for the Basslink investigations (566 person-days). The Basslink investigations have relied on helicopter access, landings on instream cobble bars during periods with the power station shut down, and helicopter drops of small boats into specific reaches.

In summary, public use of the Middle Gordon River is extremely limited, and comprises the occasional fishers, kayakers/rafters, and research personnel. There are no anticipated changes to the pattern of public use arising from the Basslink development, other than potential for increased scientific research at a level agreed to with the PWS.

Appendix 13 flags two potential future developments worthy of further consideration, in relation to public use of the Middle Gordon River:

- A collaborative scientific research station at Strathgordon, for use by Hydro Tasmania, PWS, University of Tasmania, other academic institutions and visiting researchers, and concentrating on the Gordon catchment and TWWHA.
- The potential for increasing rafting/kayaking access to the Middle Gordon River. This would either require dedicated shutdowns or reduced discharge from the Gordon Power Station to allow access, or improvements to access, to the Denison River via the northern end of Lake Gordon.

3.7.5 Industries Affected and Economic Impacts

The only industries potentially affected by operations of the Gordon Power Station, and more specifically alterations arising from Basslink, are those located in Macquarie Harbour. There are no commercial industries in the Middle Gordon River, and the public usage of this part of the river is unlikely to be impacted by Basslink.

The industries located in Macquarie Harbour which may be affected by Basslink are aquaculture businesses. These are considered in Sections 5.6 and 0 of this report.

3.8 Assessment of World Heritage Area Values

3.8.1 Basslink IIAS Requirements

As shown in Section 1.2 of this report, the IIAS Guidelines have very specific requirements for the assessment of the impact of Basslink on the Tasmanian Wilderness World Heritage Area.

Specific requirements of this section, and where they are addressed in this report, were shown in Section 1.2 and are repeated here:

1. *Description of existing regulated condition.* Provided in Section 3.2.1 of this report, on Gordon hydrology.
2. *Determination of WHA values potentially impacted.* Provided here, in Section 3.8 of this report.
3. *Description of methods to assess impacts on WHA values.* Disseminated as appropriate throughout Sections 3.2 through 3.9 of this report.
4. *Determination of sufficient baseline data.* Considered in Section 3.8.6 of this report.
5. *Results of environmental studies and mitigation proposals to enhance protection of WHA values.* Disseminated as appropriate throughout Sections 3.2 through 3.9 of this report.
6. *Proposed monitoring program.* Provided in Section 3.10 of this report.

Appendix 14, which is summarised here in Sections 3.8.2 to 3.8.6, provides background information on the nomination of the TWWHA, and assesses the implications of the Basslink research on the values for which the area was nominated. This appendix specifically addresses item 2 on the above list, and all other items on the list are addressed in the specified sections of this summary report.

3.8.2 Background on the TWWHA Nomination

The Tasmanian Wilderness World Heritage Area (TWWHA) has nationally and internationally significant natural and cultural values that were formally recognised under the World Heritage Convention in 1982 and 1989. The TWWHA represents 20% of Tasmania's land mass (1.38 million hectares). The TWWHA is one of only 22 properties of the 630 listed as World Heritage Area worldwide which were nominated for both natural and cultural values.

The 1981 nomination for World Heritage status did not include Lake Gordon and the Gordon River from the dam site to the Olga River. These middle reaches of the Gordon River were considered as a buffer zone to the nomination. There were no specific values mentioned in the 1981 nomination for the Gordon River from the Olga confluence upstream to Lake Gordon.

The Middle Gordon River was included in the 1989 nomination for World Heritage status. The gorge systems found throughout the Gordon River, the extensive riparian vegetation and the importance of the meromictic lakes on the Lower Gordon River were highlighted in the nominations. By the time of the 1989 nomination, the Gordon River had experienced more than 15 years of flow regulation associated with power generation. Therefore the existing operation of the Gordon Power Station at the time of nomination had implications for the natural and cultural values associated with the TWWHA.

3.8.3 Other Approaches to Determination of Values

The Gordon River from the dam site to the confluence with the Franklin River is presently zoned as wilderness under the TWWHA Management plan. This zone provides for limited recreation with no new facilities or mechanised access. The wilderness objectives allow, *inter alia*, natural processes to operate with minimal interference. "Given that the Gordon River system has operated in a modified flow regime for over 22 years, natural riverine processes have not operated with minimal interference" (p.2 of plan).

More recently, the proposed Protected Environmental Values (PEVs) for the Middle Gordon River determined after an extensive consultation process involving all relevant stakeholders, that the waters below Lake Gordon require protection of aquatic ecosystems, but they are modified (not pristine) ecosystems. These PEVs are part of the State Policy on Water Quality Management 1997, as was described in Section 1.3.1 of this report.

3.8.4 Environment Australia Interpretation on WHA Values

Environment Australia (EA) has developed an interpretation of the draft World Heritage values for the four natural and three cultural values of the TWWHA, available on the Commonwealth EA web site http://www.environment.gov.au/heritage/awhg/worldheritage/sites/tasmania/index.html and shown here as Table 3.11.

Table 3.11 Tasmanian Wilderness World Heritage Area Commonwealth Environment Australia World Heritage Values

Criteria against which the Tasmanian Wilderness was inscribed on the World Heritage List in 1989 following extension of the original area listed in 1982	**Examples of World Heritage natural values of the Tasmanian Wilderness for which the property was inscribed on the World Heritage List in 1989 following extension of the original area listed in 1982**

Natural criterion (i)
outstanding examples representing the major stages of the earth's evolutionary history.
	The Tasmanian Wilderness is an outstanding example of representing major stages of the earth's evolutionary history. The World Heritage values include:
	• Geological, geomorphological and physiographic features, including:
	  • Rock formations including Precambrian rocks and Cambrian rocks;
	  • Late Cambrian to Early Ordovician sequences of the Denison Range;
	  • Fossiliferous Ordovician limestone;
	  • Permian-Triassic sediments and associated Jurassic dolerite intrusions;
	  • Darwin Crater and Lake Edgar fault;
	  • Karst systems including glacio-karstic features;
	  • Karst geomorphology and karst hydrology;
	  • Glaciation, including glacial deposits of the Late Cainozoic; Permo-Carboniferous and Precambrian;
	  • Extraglacial areas;
	  • Periglaciation;
	  • Soils (e.g. peatlands); and
	  • Undisturbed river systems which show particular geomorphological processes.
	• Relict biota which shows links to adjacent Gondwanan biota including:
	  • Endemic confers;
	  • Plant species in the families *Cunoniaceae*, *Escalloniaceae* and *Winteraceae*;
	  • The plant genera *Bellendena*, *Agastachys* and *Cenarrhenes* in the *Proteaceae*;
	  • Other plant genera with Gondwanan links (e.g. *Eucryphia*, *Orites*, *Lomatia* and *Nothofagus*);
	  • Monotremes (e.g. platypus, short beaked echidna);
	  • *Dasyurid* species;
	  • Parrots (e.g. orange-bellied parrot and ground parrot);
	  • Indigenous families of frogs with Gondwanan origins (e.g. Tasmanian froglet, brown froglet, Tasmanian tree frog, brown tree frog);
	  • Invertebrate species in the genera *Euperipatoides* and *Ooperipatellus*;
	  • The Tasmanian cave spider (*Hickmania* troglodytes);
	  • Aquatic insect groups with close affinities to groups found in South America, New Zealand and Southern Africa (e.g. dragonflies, chironomid midges, stoneflies, mayflies and caddisflies).

Natural criterion (ii) outstanding examples representing significant ongoing geological processes, biological evolution and human interaction with the natural environment.	The Tasmanian Wilderness has outstanding examples representing significant ongoing geological processes and ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water and coastal ecosystems and communities, including: • Sites where processes of geomorphological and hydrological evolution are continuing in an uninterrupted natural condition (including karst formation, periglaciation which is continuing on some higher summits), fluvial deposition, evolution of spectacular gorges, marine and aeolian deposition and erosion, and development of peat soils and blanket bogs) • Ecosystems which are relatively free of introduced plant and animal species; • Coastal plant communities free of exotic sand binding grasses which show

	natural processes of dune formation and erosion; • Undisturbed catchments, lakes and streams; • Alpine ecosystems with high levels of endemism; • The unusual cushion plants (bolster heaths) of alpine ecosystems; • Ecological transitions from moorland to rainforest; • Pristine tall eucalypt forests; • Examples of active speciation in the genus Eucalyptus, including sites of: hybridisation and introgression; clinal variation; habitat selectional and transition zones which include genetic exchanges between *Eucalyptus* species; • Plant groups in which speciation is active (e.g. *Gonocarpus*, *Ranunculus* and *Plantago*); • Confers of extreme longevity (e.g. Huon pine, Pencil pine, King Billy pine); • Endemic members of large Australian plant families (e.g. heaths); • Endemic members of invertebrate groups; • Invertebrate species in isolated environments, especially mountain peaks, offshore islands and caves with high levels of genetic and phenotypic variation; • Invertebrates of unusually large size (e.g. giant pandini moth); • Invertebrate groups which show extraordinary diversity (e.g. land flatworms, large amphipods, peripatus, stag beetles, stoneflies); • Skinks in the genus *Leiolopisma* which demonstrate adaptive radiation in alpine heaths and boulder fields on mountain ranges; • Examples of evolution in mainland mammals; • Animal and bird species whose habitat elsewhere is under threat; and • The diversity of plant and animal species.

Natural criterion (iii) contains superlative natural phenomena, formations or features, for instance outstanding examples of the most important ecosystems, areas of exceptional beauty or exceptional combination of natural and cultural elements.	The landscape of the Tasmanian Wilderness has exceptional natural beauty and aesthetic importance and contains superlative natural phenomena including:
	• Viewfields of exceptional natural beauty associated with:
	    • Flowering heaths of the coastline;
	    • The south and south-west coasts comprising steep headlands interspersed with sweeping beaches, rocky coves and secluded inlets;
	    • Eucalypt tall open forests including *Eucalyptus regnans*, the tallest flowering plant species in the world;
	    • Rainforests framing undisturbed rivers;
	    • Buttongrass, heath and moorland extending over vast plains;
	    • Wind-pruned alpine vegetation;
	    • Sheer quartzite or dolerite capped mountains (including Cradle Mountain, Frenchmans Cap, Federation Peak and Precipitous Bluff);
	    • Deep, glacial lakes, tarns, cirques and pools throughout the ranges;
	    • The relatively undisturbed nature of the property;
	    • The scale of the undisturbed landscapes;
	    • The juxtaposition of different landscapes;
	    • The presence of unusual natural formations (e.g. particular types of karst features) and superlative examples of glacial landforms and other types of geomorphic features; and
	    • Rare or unusual flora and fauna.

Natural criterion (iv) contain the most important and significant habitats where threatened species of plants and animals of outstanding universal value from the point of view of science and conservation still survive.	The ecosystems of the Tasmanian Wilderness contain important and significant natural habitats where threatened species of animals and plants of outstanding universal value from the point of view of science and conservation still survive, including: • Habitats important for endemic plant and animal taxa and taxa of conservation significance, including: • Rainforest communities, alpine communities, moorlands (e.g. in the far south-west), riparian and lacustrine communities (including meromictic lakes). • Habitats which are relatively undisturbed and of sufficient size to enable survival of taxa of conservation significance including endemic taxa;

	• Plant species of conservation significance; • Animal species of conservation significance, such as: • Spotted-tail quoll (*Dasyurus maculatus*); swamp antechinus (*Antechinus minimus*); broad-toothed rat (*Mastocomys fuscus*); ground parrot (*Pezoporus wallicus*); orange-bellied parrot (*Neopheina chrysogaster*); Lake Pedder galaxias (*Galaxias pedderensis*); and Pedra Blanks skink (*Niveoscincus palfreymani*).
Cultural criterion (iii) bears a unique or at least exceptional testimony to a civilization which has disappeared.	The Tasmanian Wilderness bears a unique and exceptional testimony to an ancient ice age society, represented by: • Pleistocene archaeological sites that are unique, of great antiquity and exceptional in nature, demonstrating the sequence of human occupation at high southern latitudes during the last ice age.
Cultural criterion (v) an outstanding example of a traditional human settlement which is representative of a culture which has become vulnerable under the impact of irreversible change.	The Tasmanian Wilderness provides outstanding examples of a significant, traditional human settlement that has become vulnerable under the impact of irreversible socio-cultural or economic change. The World Heritage values include: • Archaeological sites which provide important examples of the hunting and gathering way of life showing how people practiced this way of life over long time periods, during often extreme climatic conditions and in contexts where it came under the impact of irreversible socio-cultural and economic change.
Cultural criterion (vi) directly or tangibly associated with events or with ideas or beliefs of outstanding universal significance.	The Tasmanian Wilderness is directly associated with events of outstanding universal significance linked to the adaptation and survival of human societies to glacial climatic cycles. The World Heritage values include: • Archaeological sites including Pleistocene sites, which demonstrate the adaptation and survival of human societies to glacial climatic cycles and periods of long isolation from other communities (e.g. the human societies in this region were the most southerly known peoples on earth during the last ice age).

SOURCE: ENVIRONMENT AUSTRALIA 2000

3.8.5 Assessment of Basslink Implications for WHA Values

The author of Appendix 14 reviewed all of the appendices in this report series relevant to the Gordon River (Appendices 2-13, summarised in Sections 3.1 to 3.7 of this report), and conducted interviews with key researchers. This assessment was focussed on the Basslink development without mitigation measures to minimise impacts. The outcomes of the Gordon River Basslink investigations were assessed in relation to the four natural and three cultural TWWHA criterion set out in Table 3.11, with the following conclusions:

- **Natural criterion (i)** – Continued erosion of sandy alluvial banks under Basslink, and ongoing adjustments of cobble bars and other extraglacial features, may have implications for the extraglacial values for which the TWWHA was nominated. The riverbanks are an evolutionary feature detailed in natural criterion (i), outstanding examples representing major stages of the earth's evolutionary history. The geomorphic evolution of the Gordon riverbanks is presently affected by power station influences, and is likely to continue to be affected by Basslink. Specifically, under Basslink without any mitigation measures in place, there are anticipated to be increases in the probabilities of erosion due to scour, and increases in the occurrence but decreases in the severity of seepage-induced erosion, leading to continued adjustments of riverbank profile but no change to river planform.

- **Natural criterion (ii)** – Changes associated with Basslink are not anticipated to affect the TWWHA as having outstanding examples representing significant ongoing geological processes, biological evolution and human interaction with the natural environment. Importantly, the Gordon

River does not represent ‘undisturbed catchments, lakes and streams’, as it is a regulated and modified river.

- **Natural criterion (iii)** – Changes associated with Basslink are not anticipated to affect the TWWHA as containing superlative natural phenomena, formations or features, for instance outstanding examples of the most important ecosystems, areas of exceptional beauty or exceptional combination of natural and cultural. ‘Undisturbed rivers’ are specifically mentioned. Superlative natural phenomena would include spectacular bedrock features in the Middle Gordon River such as the Splits, but these are bedrock and not prone to influence by power station operations.

- **Natural criterion (iv)** – Changes associated with Basslink are not anticipated to affect the TWWHA as containing the most important and significant habitats where threatened species of plants and animals of outstanding universal value from the point of view of science and conservation still survive. Basslink without mitigation is anticipated to affect Gordon River habitat areas including the riparian zone, instream channel and islands relative to the existing condition, most particularly in the reaches upstream of the Denison River. Specifically, Basslink is anticipated to accelerate the current power station impacts on riparian vegetation, which are a reduction in the species cover and diversity. There are no anticipated Basslink impacts for any species listed under the Tasmanian *Threatened Species Protection Act* 1995.

- **Cultural criterion (iii)** – Changes associated with Basslink are not anticipated to affect the TWWHA as an area that bears a unique or exceptional testimony to a civilisation which has disappeared, because no cultural heritage sites are known to have been impacted by power station operations.

- **Cultural criterion (v)** – Changes associated with Basslink are not anticipated to affect the TWWHA as an area that provides an outstanding example of a traditional human settlement which is representative of a culture which has become vulnerable under the impact of irreversible change, because no cultural heritage sites are known to have been impacted by power station operations.

- **Cultural criterion (vi)** – Changes associated with Basslink are not anticipated to affect the TWWHA as an area that is directly or tangibly associated with events or with ideas or beliefs of outstanding universal significance, once again because no cultural heritage sites are known to have been impacted by power station operations.

3.8.6 Conclusions of WHA Values Assessment

Appendix 14 assessed what natural and cultural values of the Tasmanian Wilderness World Heritage Area might be potentially affected by the proposed Basslink project on the Gordon River. Seven TWWHA criterion were assessed (four natural and three cultural), with projected Basslink changes (in the absence of mitigation measures) having implications for two natural criteria:

- The potential for increased erosion has implications for natural criterion i (outstanding examples representing the major stages of the earth’s evolutionary history); and

- Accelerated losses of vegetation species cover and diversity in the riparian zone has implications for natural criterion iv (important and significant habitats where threatened species of plants and animals of outstanding universal value from the point of view of science and conservation still survive). Basslink is not predicted to affect any threatened species of plants and animals in the Gordon River, and the riparian vegetation is already degraded by present operations.

The two of the seven TWWHA criterion which have been identified refer to features that are represented in the Middle Gordon River, and are influenced by both present and Basslink operating regimes for the Gordon Power Station. Given that these features are not unique and are well-represented throughout the TWWHA, the influence of the power station does not substantially impact on the overall integrity of the TWWHA.

Basslink without mitigation represents a further modification to the present impacts of river regulation. There are, however, substantial river improvement measures to which Hydro Tasmania commits (see Section 3.9.7). Basslink in fact offers the potential for implementation of substantial river rehabilitation measures, which is in keeping with Australia's commitments to restoration of WHA values wherever possible. Therefore, this assessment concludes that Basslink does not substantially degrade the WHA values for which the TWWHA was declared, and in fact may provide some opportunity to enhance values.

The JAP requires the Basslink IIAS to assess whether there is sufficient baseline data to assess the impact of Basslink on the TWWHA. These investigations have provided very good insights into the present state of the Middle Gordon River, and identify the types and extent of changes that could be anticipated to occur with Basslink operation of the Gordon Power Station. This information has been sufficient to draw the conclusions presented in Section 3.8. Additional information is unlikely to change these conclusions, but rather allow refinement of theories and more precise quantification of spatial and temporal variability, processes and rates.

3.9 Gordon River Environmental Issues and Mitigation Options

3.9.1 Approach

The Basslink IIAS requires an assessment of Basslink changes to Hydro Tasmania-affected waterways compared to present conditions. Present environmental conditions in the waterways are, however, a response to historic power station operations and are not necessarily in equilibrium. Therefore it is valuable to understand present trends in environmental conditions, in order to appreciate predicted Basslink trends. For each study undertaken on the Gordon River, the following section (3.9.2) very briefly summarises the researchers conclusions, specifically identifying the changes in condition which have already occurred compared to the pre-dam condition, the present trends in these conditions, and the Basslink trends (relative to present trends).

Section 3.9.3 provides a general overview of the key Basslink environmental management issues. Section 3.9.4 summarises available mitigation options. Sections 3.9.5 and 3.9.6 examine specific water management mitigation options more closely, in terms of business costs to Hydro Tasmania, environmental benefits for the targeted environmental management issue, and implications for other aspects of the Gordon River ecosystem.

Section 3.9.7 summarises the proposed environmental mitigation for the Basslink development to be implemented on the Gordon River by Hydro Tasmania.

3.9.2 Conclusions from the Individual Gordon River Studies

3.9.2.1 Gordon River Hydrology

- *Changes Compared to Pre-Dam Conditions* - Curtailing of major floods, more restricted flow range, less variability in flows.
- *Present Trends* – Inter-annual variability in power station operations between wet and dry years (more generation in dry years), seasonal variability with more continual discharge in summer

using 2-3 generators and less discharge in winter, and daily variability depending on the daily load requirements and water availability in other storages.

- *Basslink Trends* – Reduced inter-annual variability, more continual discharge throughout the year including more winter discharge, daily fluctuations from off to full capacity discharges, more frequent weekend shutdowns of the power station. Predictions of increased occurrence of full capacity discharges under Basslink are in fact due to the limitations on the power station discharges during the comparative historical years (1997-98), and so this change can not be fully attributed to Basslink.

3.9.2.2 Gordon River Water Quality

- *Changes Compared to Pre-Dam Conditions* – Reduced summer dissolved oxygen and temperature releases; note that D.O. increases rapidly downstream of the tailrace.
- *Present Trends* – Variability on a seasonal basis, and in an inter-annual basis depending on level in Lake Gordon.
- *Basslink Trends* – Consistently lower lake levels result in somewhat warmer temperatures of summer power station discharges, and reduce the risk of low D.O. releases. Downstream from the power station, there is entry of water of a seasonal temperature from tributaries on a daily but fluctuating basis.

3.9.2.3 Gordon River Fluvial Geomorphology

- *Changes Compared to Natural* – Alluvial sections upstream of the Splits significantly modified by power station operations, erosion features are concentrated at the high water mark (HWM), banks are largely devegetated below the two-turbine on water level, saturation of the banks leads to seepage-induced erosion, impact diminishes with distance downstream of the Denison River, and the Albert River has exacerbated erosion at the mouth. Bed load sizes have decreased, and bed armouring has occurred. Rates of change significantly increased.
- *Current Trends* – Incursion of new vegetation upstream of Abel Gorge and in gorge sections down to the HWM, where previously floods did not permit colonisation. Erosion is very active and far from in equilibrium between the Gordon Power Station and the Splits. Riverbank slope profiles will continue to adjust over the long-term due to scour and seepage processes. Channel widening and narrowing are documented, but are not anticipated to result in planform changes to the river system beyond the localised widening of alluvial ‘pockets’. The Albert River will continue to widen at the mouth.
- *Basslink Trends* – Basslink will result in changes to the geomorphic processes controlling stability of the Gordon River banks, notably with an increase in the probabilities of scour, and an alteration to conditions leading to bank saturation, thus modifying seepage erosion processes. The average annual number of drawdown events increases significantly with Basslink, which may lead to an increase in the occurrence of seepage-induced erosion, but probably not an increase in severity because banks are less saturated. Basslink changes are anticipated to be limited to adjustments of alluvial bank profiles, but no change to river planform compared to existing effects of flow regulation.

3.9.2.4 Gordon River Karst Geomorphology

- *Changes Compared to Pre-Dam Conditions* – Deposition of 30-40 cm thick sediment banks in the first 50-60 m of the cave where previously gravels were found.
- *Present Trends* – Inundation of Bill Neilson cave on a regular basis about 2 m above the cave entrance floor, extending to an estimated maximum of 180 m from the entrance. Possibly ongoing deposition of the sediment banks.

- *Basslink Trends* – Sediment banks near entrance may experience more active deposition, as well as active slumping and collapse from recurrent saturation and dewatering. Because these are likely to be a post-dam feature, they are not considered to be of high conservation value. Inundation of a previously dry sediment bank may occur due to the higher probability of peak station discharge occurring simultaneously with high catchment flows.

3.9.2.5 Gordon River Riparian Vegetation

(Note that bank heights reflect channel morphology upstream of the Splits).

- *Changes Compared to Pre-Dam Conditions* – A general reduction in terrestrial species cover and diversity, removal of vegetation up to 1.5 m above the low water mark (LWM), changing species composition from 1.5 – 2.5 m above LWM due to waterlogging and inundation, lack of regeneration and recruitment up to 2.5 m, changing species composition from 2.5 – 4 m due to lack of floods. Vegetation-covered islands are eroding and experiencing species loss. Adjustments upstream Splits are most pronounced, decreasing with distance downstream.
- *Present Trends* – Continuation of these effects, slow process of erosion particularly on central channel islands. No new recruits to the zone between LWM and HWM means that the banks most particularly u/s of the Splits will eventually end up with a high percentage cover of mineral substrates and grasses up to 2.5 m above LWM. Ephemerals may take advantage of this, mostly grasses, gramonoids (grass-like plants) and tolerant semiaquatic herbs, which may provide some structural stability to river banks. Loss of principal tall woody shrub species *Leptospermum riparium*.
- *Basslink Trends* – Accelerates rates of present trends. Accelerated decline of island vegetation. Existing zone of predominantly mineral substrate from LWM to 1.5 m will increase in extent to reach 2.5 m on the bank. Existing 1.5-2.5 m zone migrates up to occupy 2.5-4 m zone, with a loss of the existing 2.5-4 m zone. No changes above 4 m due to Basslink. Changes to the risk of inundation and waterlogging should occur, however the lack of regeneration and recruitment means the majority of the vegetation, particularly u/s of the Splits, to a height of approximately 2.5 m above LWM, will die and not be replaced in the long-term.

3.9.2.6 Gordon River Macroinvertebrates

- *Changes Compared to Pre-Dam Conditions* – Upstream of Denison River confluence, invertebrate communities are significantly to severely impacted, and downstream of the Denison River confluence to the Franklin River confluence are moderately impacted when compared to unregulated tributaries of the Gordon River. Loss of species diversity and reduction in abundance. Loss of edge and snag habitat availability (‘upper tidal’ zone), and decrease in ‘mid-tidal’ zone and ‘thalweg’ zone (mid-channel) habitat quality throughout Middle Gordon River.
- *Present Trends* – Continuation of these effects with different trends for the three zones. ‘Thalweg zone’ in quasi-equilibrium; ‘mid-tidal’ zone colonising over periods of several months, if experiencing continued inundation; ‘upper tidal’ zone experiences short-term fluctuations and is severely impacted with no macroinvertebrates.
- *Basslink Trends* – Shifts from a 3-zone to a 2-zone within-channel system. ‘Thalweg zone’ communities adjust to a new quasi-equilibrium with a significantly lower abundance and diversity than at present. ‘Mid-tidal’ zone disappears. ‘Upper tidal’ zone with no macroinvertebrates becomes broader downslope to meet the thalweg zone. Further loss of snag habitat availability, as shorter periods of inundation are not long enough for colonisation. Longitudinal extension of impacts – losses in ‘thalweg zone’ upstream of Denison River of up to 50% of extant taxa (i.e. a drop of 0.2-0.3 O/E relative to the present mean of 0.5), and up to 20% of taxa downstream of Denison River (a drop of 0.1-0.2 O/E relative to present mean of 0.9), and both sections experience further decreases in abundance.

3.9.2.7 Gordon River Fish

- *Changes Compared to Pre-Dam Conditions* – Reduced populations of native fish in river and tributaries, gradually increasing with distance downstream. The power station also affects tributary populations. Reduced fish migration opportunities at gorges, lack of recruitment to upstream reaches, reversed seasonality of flows affects spawning and migration cues, reduced macroinvertebrate food supplies, loss of snag habitat, stranding issues, impacts due to trout which dominate the upper reaches (introduced in the late 1800s).
- *Present Trends* – Native populations in upper reaches and tributaries are growing older and will probably die out due to lack of recruitment. This is caused by fish migration difficulties due to sustained high flows during the warmer months. Main river channel fish populations are in a quasi-equilibrium condition.
- *Basslink Trends* – Reduced habitat availability within Gordon River and reduced food may lead to further reduced fish populations. Increased windows of opportunity for upstream native fish migrations with shutdowns, which will improve recruitment to upper reach and tributary populations. Longitudinal extent of impacts to populations unlikely to change from existing conditions.

3.9.2.8 Gordon River Platypus and Native Water Rats

- *Changes Compared to Pre-Dam Conditions* – unknown. There are existing populations of platypus and water rats in the catchment area. Platypus are unlikely to be resident in the Gordon River itself.
- *Present Trends* – No data, can only speculate. Decrease in availability of macroinvertebrate food on which platypus are totally dependent. Decrease in habitat availability especially for juveniles. Decrease in habitat quality for all life stages. Probable loss of burrow habitat with bank erosion. Possible issue with upstream passage such as at the Splits.
- *Basslink Trends* – Further decrease in macroinvertebrate food availability, and increase in variability of velocities may lead to incremental decrease in numbers of juvenile platypus. Possible benefit with increased dispersal opportunities through gorges with weekend shutdowns.

3.9.2.9 Terrestrial Fauna associated with the Gordon River

- *Changes Compared to Pre-Dam Conditions* – No baseline data available.
- *Present Trends* – No data available, probably in quasi-equilibrium.
- *Basslink Trends* – No impacts anticipated.

3.9.2.10 Gordon River Cave Flora and Fauna

- *Changes compared to Pre-Dam Conditions* – No baseline data available.
- *Present Trends* – Probably in quasi-equilibrium.
- *Basslink Trends* – No changes unless eventual loss of siltbanks near entrance which may result in localised impacts on some species.

3.9.2.11 Gordon River Meromictic Lakes

- *Changes Compared to Pre-Dam Conditions* – Data suggest that Lake Morrison and Sulphide Pool have largely lost their meromixis (stratified state with freshwater at top and saline water at depth), although it is not clear if these lakes naturally vacillated between the two states (stratified and unstratified). Lake Fidler is in danger of losing its long-term meromixis without saline water recharge.

- *Present Trends* – Lake Fidler is trending towards holomixis (uniformity throughout its depth). Lake Fidler is still meromictic, however the chemocline (zone of change between the saline and fresh strata) is deeper than during previous research. There is some evidence to suggest that this lake also has 'turned over'. The trend towards holomixis is most likely due to the operation of the Gordon Power Station during naturally 'dry' times of the year, thus preventing saline recharge of these lakes. It is likely that continued depletion of the monimolimnion (zone of higher salinity at bottom of lake) in Lake Fidler will occur.
- *Basslink Trends* – No change is predicted due to Basslink. All saline recharge opportunities in past years have been associated with long maintenance shutdowns. Basslink will not affect the timing or duration of these shutdowns.

3.9.3 Gordon River Key Basslink Environmental Issues

3.9.3.1 Basslink Impacts Requiring Mitigation

This section extracts from the previous section the aspects of the Gordon River ecosystem most subject to fundamental and adverse changes due to Basslink – geomorphology, riparian vegetation, macroinvertebrates, and fish – in the absence of the substantial mitigation measures to which Hydro Tasmania commits.

These impacts are re-iterated here. Note that trends are with reference to changes from present trends:

- *Basslink Trends for Fluvial Geomorphology* – Basslink will result in changes to the geomorphic processes controlling stability of the Gordon River banks, notably with an increase in the probabilities of scour, and an alteration to conditions leading to bank saturation, thus modifying seepage erosion processes. Basslink changes are anticipated to be limited to adjustments of alluvial bank profiles, but no change to river planform compared to existing effects of flow regulation.
- *Basslink Trends for Riparian Vegetation* – Accelerates rates of present trends, but results in the same end-point as existing regime for the river banks u/s of the Splits between LWM and 1.5 m. Accelerated decline of island vegetation. Existing zone of predominantly mineral substrate from LWM to 1.5 m will increase in extent to reach 2.5 m on the bank. Existing 1.5-2.5 m zone migrates up to occupy 2.5-4 m zone, with a loss of the existing 2.5-4 m zone. No changes above 4 m due to Basslink. Changes to the risk of inundation and waterlogging should occur, however the lack of regeneration and recruitment means the majority of the vegetation, particularly u/s of the Splits, to a height of approximately 2.5 m above LWM, will die and not be replaced in the long-term.
- *Basslink Trends for Macroinvertebrates* – Shifts from a 3-zone to a 2-zone within-channel system. 'Thalweg zone' communities adjust to a new quasi-equilibrium with a significantly lower abundance and diversity than at present. 'Mid-tidal' zone disappears. 'Upper tidal' zone with no macroinvertebrates becomes broader downslope to meet the thalweg zone. Further loss of snag habitat availability, as shorter periods of inundation are not long enough for colonisation. Longitudinal extension of impacts – losses in 'thalweg zone' upstream of Denison River of up to 50% of extant taxa (i.e. a drop of 0.2-0.3 O/E relative to the present mean of 0.5), and up to 20% of taxa downstream of Denison River (a drop of 0.1-0.2 O/E relative to present mean of 0.9), and both sections experience further decreases in abundance.
- *Basslink Trends for Fish* – Reduced habitat availability within Gordon River and reduced food may lead to further reduced fish populations.

Hydrology is not included because it is a cause and not an effect. Water quality has not been included here because the changes are generally believed to be beneficial. Karst and cave fauna are not included because the only predicted Basslink changes are with small post-dam sediment deposits near the cave entrance which are of no conservation significance. Platypus and water rats are not specifically included here because impacts to their populations most largely follow the discussion of macroinvertebrates which is an important food source. Finally, terrestrial fauna and meromictic lakes are not included because there are no anticipated Basslink issues.

3.9.3.2 Environmental Benefits of Basslink

Aspects of the Basslink operating regime result in improvements to present environmental conditions in the Middle Gordon River. These notably include:

- Basslink holds Lake Gordon somewhat lower in its operating range compared to historical operations, which reduces the risk of low dissolved oxygen and seasonally cooler water being drawn into the power station intake; and
- The increased occurrence of short-term and weekend power station shutdowns provides more opportunity for fish passage and platypus dispersal in the Middle Gordon River.

3.9.4 Gordon River Basslink Mitigation Options

For the four areas of research which result in significant Basslink impacts, the mitigation options identified by researchers to address Basslink impacts are summarised below (note that options that address existing effects of power station operations are not listed).

- *Mitigation Options for Fluvial Geomorphology* - a re-regulation dam, physical buttressing of the banks, reduction of the maximum power station discharge (to reduce zone of bank saturation), partial power station ramp-downs or step-downs or similar measure (to reduce phreatic surface gradients in banks), minimising the duration of three generator discharge (to reduce extent of bank saturation), maintenance of a minimum environmental flow (to lessen scour of bank toe and reduce phreatic surface gradient), or a combination of these.

- *Mitigation Options for Riparian Vegetation* – minimising the duration and/or magnitude of maximum discharges, and implementing options to minimise bank erosion.
- *Mitigation Options for Macroinvertebrates* - a re-regulation dam, minimum environmental flows (to ensure watering of the 'mid-tidal' zone and inundation of marginal snag habitats), and ramp-downs (would have to be very slow for macroinvertebrates). It should be noted that a minimum environmental flow to maintain habitat for macroinvertebrates also partially maintains food supply for fish and platypus.
- *Mitigation Options for Fish* – provision of small (<10 m^3/s) minimum environmental flow for fish habitat availability, partial ramp-downs of power station discharges (to reduce stranding), options that improve macroinvertebrate populations as food supply for the fish, manually restocking with natives.

As can be seen, the vast majority of these options involve changes to the operation of the Gordon Power Station, with a re-regulation weir, physical buttressing of the banks, and re-stocking with native fish being the only non-water management options identified.

Additional proposals for mitigation which have been suggested include changes to operational policies to favour Poatina as a peaking station over Gordon, and to have Gordon Power Station adjustments made in response to real-time data on bank saturation in order to avoid seepage-induced erosion. Both of these have been examined by Hydro Tasmania and ruled out as not feasible. Favouring Poatina as a peaking station over Gordon would lead to long-term generating system imbalances and would cause unacceptable risks to Hydro Tasmania's ability to meet power demand. Gordon Power Station operational changes in response to bank saturation levels is not only technically very difficult if not unfeasible, but also allows no security in operating patterns, which is unacceptable if Hydro Tasmania is putting in bids for delivery of electricity and for security of electricity supply in Tasmania. These options are not further considered.

The process followed to assess mitigation options involved several 'workshop' style meetings with the key Gordon River researchers, and separate cost assessments of the different mitigation options undertaken by the Hydro Tasmanian System Studies group.

Only three of the options did not require water management changes at the power station. A re-regulation dam has the potential to mitigate Basslink environmental impacts as well as improve present environmental conditions, but has been discounted as it would need to inundate at a minimum all of the river valley between the Gordon Dam and Abel Gorge, and the environmental costs of this option were viewed as being much higher than the environmental benefits. Physical buttressing of the banks and restocking with native fish have great potential to meet their mitigation objectives, but were viewed as not necessarily in keeping with the World Heritage Area management guidelines for the Gordon River which specify that natural processes should govern management actions. It is anticipated that the physical buttressing of unstable riverbanks may be unfeasible due to logistical constraints, costs, and requirements for power station shutdown time; however, some trials of this option may be of interest to pursue.

The researchers' proposed Basslink water management mitigation options are listed below, along with the primary disciplines for which each option was proposed.

- Minimising the duration and/or magnitude of maximum power station discharges (fluvial geomorphology, riparian vegetation);
- Minimum environmental flow (aquatic macroinvertebrates, fluvial geomorphology); and
- Power station ramp-downs or comparable measure (fluvial geomorphology, aquatic macroinvertebrates, fish).

Minimising the duration and/or magnitude of maximum power station discharges was considered beneficial by the fluvial geomorphology and riparian vegetation researchers in restricting the height of impact on the river bank faces, but only of minor benefit in terms of the instream biota (macroinvertebrates, fish, platypus, water rats). However, the need for such a Basslink mitigation option arises from the hydrological analyses which show that under Basslink the Gordon Power Station discharges at flows greater than 210 m^3/s considerably more of the time (from 9% to 29%) than under historical conditions (Figure 3.9). This statistic, however, reflects historical operation of the power station between 1997 and 1998, when there were significant load constraints on the Gordon Power Station, as well as characteristics of the TEMSIM model (see Section 2.3.2). As of 2001, the majority of generation and transmission constraints which limited output from the Gordon Power Station during 1997-98 have been removed, and the Gordon Power Station at present is more capable of generating at full capacity. Therefore this mitigation measure was not further pursued.

The most consideration and assessment was given to the options of a minimum environmental flow and a measure to minimise phreatic surface gradients such as a ramp-down rule. These two measures comprise a best practice approach to minimising downstream impact of regulated rivers, and are considered in turn in the following sections.

3.9.5 Minimum Environmental Flow

3.9.5.1 Environmental Benefits

A minimum environmental flow is a mitigation option primarily identified to improve conditions for the instream macroinvertebrate biota, to increase the 'thalweg' wetted area, ensure watering of the 'mid-tidal' zone and inundation of marginal snag habitats. This would also result in increased habitat for fish, and improved food supply (macroinvertebrates) for fish and platypus. A minimum environmental flow was also identified as a beneficial option for the fluvial geomorphology, as it would lessen scour of the bank toe and reduce phreatic surface gradient out of the banks.

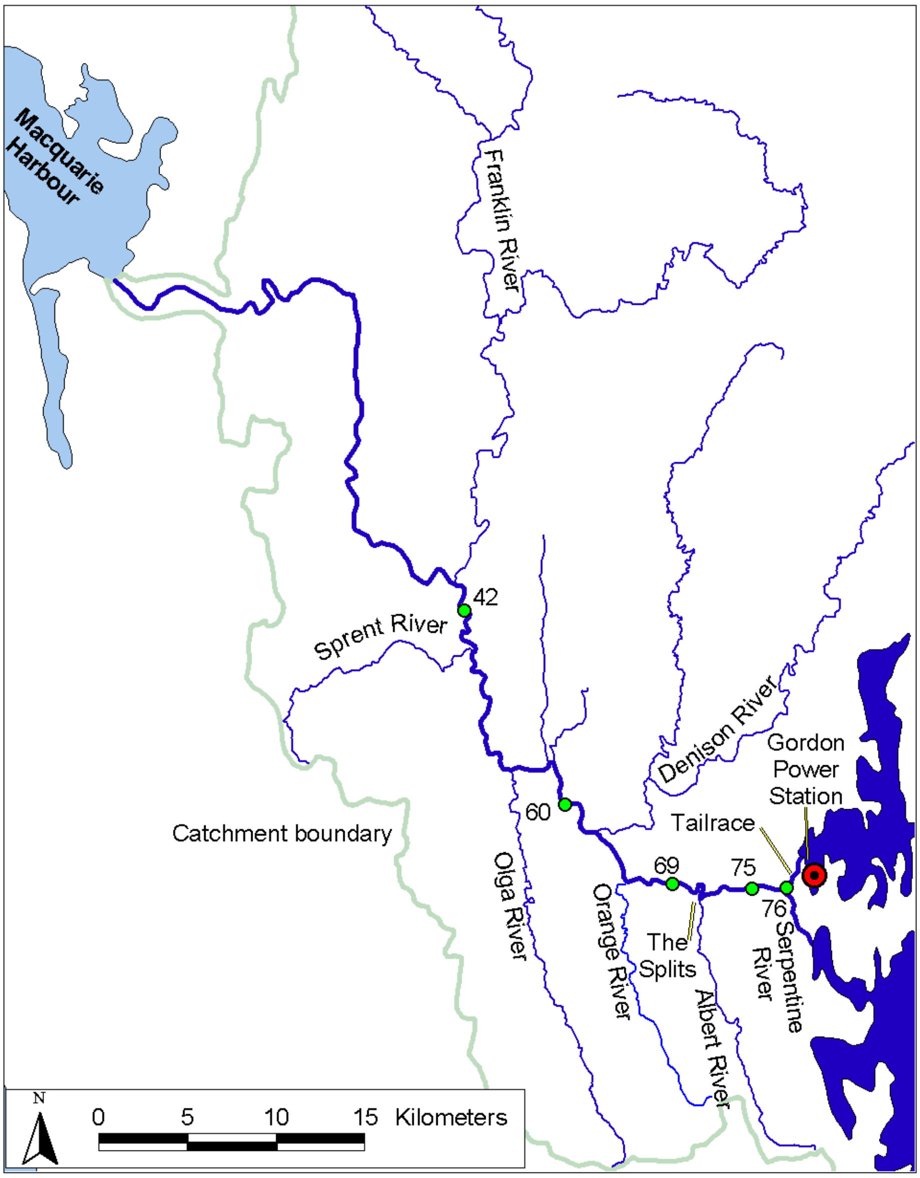
The assessment of the optimal environmental flow for the Middle Gordon River that was undertaken for these Basslink investigations was primarily focussed on benefits to the instream biota. A summary of the ecological condition of macroinvertebrate taxa at a given point in a river can be expressed as an O/E ratio, or comparison of observed versus expected taxa ('expected' based on comparison with unregulated tributary streams of the Gordon River). O/E ratios vary between 0 and 1.1, and an O/E of 1.0 indicates no impacts to the macroinvertebrate populations compared to what is expected to be present based on reference streams. This was described in more detail in Section 3.5.3, and Appendix 7.

Table 3.12 provides a summary of the present O/E scores at five selected sites downstream of the Gordon power station. Sites are shown on Map 3.12. The present O/E ratios are from the 1999-2000 Basslink investigations which are the best indication available, and are derived from a rank abundance assessment which provides the most sensitivity to changes in flow.

Table 3.12 Present and Predicted Basslink without Mitigation O/E scores for Selected Sites on the Gordon River

Site	Present O/E Ratios	Predicted Basslink O/E Ratios
76	0.41	0.2 - 0.3
75	0.54	0.35 - 0.45
69	0.44	0.25 - 0.35
60	0.80	~ 0.7
42	0.99	~ 0.9

The predicted Basslink O/E ratios in Table 3.12 are in the absence of any mitigation measures. Basslink is anticipated to impact on macroinvertebrate populations throughout the Middle Gordon River, but only marginally as far downstream as the Franklin River.



Map 3.12 Sites for assessment of benefit of a minimum environmental flow.

Table 3.13 shows a summary of the environmental benefits in terms of macroinvertebrate taxa of various minimum environmental flows. This information is presented for three different monitoring sites in the Middle Gordon River (also shown on Map 3.12), and for three different risk bands as described in Section 3.5.3.

Table 3.13 Environmental Benefits (O/E scores) with a Gordon Minimum Environmental Flow

PREDICTED O/E RATIOS FOR BASSLINK WITH MINIMUM ENVIRONMENTAL FLOW									
Where Measured	**Power Station**			**u/s Denison R.**			**u/s Franklin R.**		
Risk Band	**I**	**II**	**III**	**I**	**II**	**III**	**I**	**II**	**III**
Dec-May Flow (m^3/s)	22-26	18-23	10-18	27-36	19-27	7-19	55-66	42-55	18-42
Jun-Nov Flow (m^3/s)	43-63	33-43	22-33	49-63	38-49	25-38	73-97	53-73	32-53
Site 76	0.3-0.4	0.3-0.4	0.2 - 0.3	?	?	?	?	?	?
Site 75	0.4-0.5	0.4-0.5	0.35-0.45	?	?	?	?	?	?
Site 69	0.35-0.45	0.35-0.45	0.25-0.35	0.35-0.45	0.35-0.45	0.25-0.35	?	?	?
Site 60	0.85	0.85	~ 0.7	0.85	0.85	~ 0.7	0.85	0.85	~ 0.7
Site 42	0.95	0.95	~ 0.9	0.95	0.95	~ 0.9	0.95	0.95	~ 0.9

The main difference with choice of monitoring site is the magnitude of the environmental flow target which must be maintained. Additionally, monitoring sites downstream of the power station do not permit prediction of benefits of the environmental flow at sites upstream.

The different risk bands have different environmental flow targets associated with them, as shown in Table 3.13. These are the risk bands that were presented in Table 3.7, with the target flow ranges derived from Figure 3.14. There is no difference between the environmental benefits obtained by minimum environmental flows in the I versus II risk band, in terms of O/E scores. O/E scores obtained with an environmental flow from Risk Band C would not mitigate predicted Basslink impacts on the biota as shown in Table 3.12. O/E scores in Risk Bands I/II would improve the predicted O/E scores under a Basslink flow regime, and at some sites (e.g. Site 60) even improve on the present O/E scores.

It is concluded from Table 3.12 and Table 3.13 that a target minimum environmental flow in risk band II would successfully mitigate the impacts of Basslink on the macroinvertebrate fauna. This is consistent with the recommended range of environmental flows (within risk bank I or II) identified in Appendix 7.

3.9.5.2 Cost to Hydro Tasmania

Measurement of the environmental flow upstream of the Denison River is considered the most practical, and it is this environmental flow measuring site which has been considered in terms of potential costs to Hydro Tasmania. Measurement at the power station was not further considered because it is likely to result in larger than required releases from the Gordon Power Station if downstream natural inflows are significant. Measurement upstream of the Franklin River is considered too far downstream to use as a point of assessment of power station influence.

Using a measuring site upstream of the Denison River, and delivering an environmental flow in the II risk band, would result in maintenance of a minimum environmental flow upstream of the Denison river of between 19-27 m^3/s in summer (December through May), and 38-49 m^3/s in winter (Jun through November).

There are different mechanisms by which the flow could be delivered. Options include various engineering possibilities via the Gordon Dam or the Serpentine Dam, or through the power station. Hydro Tasmania's most financially sustainable method of delivery of an environmental flow is through the Gordon Power Station, so that there are no significant capital costs is setting up a delivery mechanism, and so some costs can be recovered via power generation.

Table 3.14 shows an assessment of the costs to Hydro Tasmania of environmental flow delivery to the Gordon River based on different delivery approaches through the power station. To determine these costs, an analysis was undertaken which examined the time periods during which the power station was not predicted to operate, and natural flow levels at the Gordon upstream of Denison River were not sufficient to meet the minimum environmental flow target, and so a supplementary release of water would be required to the Gordon River. 'No power generation' in Table 3.14 assumes the flow is delivered via some delivery mechanism at the Gordon Dam or Serpentine Dam. 'Half one-generator' (approximately 35 m^3/s depending on lake level) and 'Efficient Load One-Generator' (approximately 70 m^3/s depending on lake level) assume that whenever supplementary water to natural inflows is required at the Gordon River upstream of the Denison River to maintain the minimum environmental flow target, the power station will deliver a flow of water at these settings. Exact power generation is as it implies, the power station will discharge exactly the supplementary flow requirement to maintain the minimum environmental flow target. This table only looks at target flows in Risk Band II, measured upstream of the Denison River.

The nature of the costs to Hydro Tasmania is two-fold. The delivery of a minimum environmental flow results in lost Basslink revenue and a cost for replacing a deficiency in the Energy in Storage (EIS) in the system (Table 3.14). These costs are partially a result of the Gordon Power Station generating power at times when the smaller storages (e.g. run-of-river) are full which results in greater amounts of spill (i.e. lost energy). In addition, running Gordon Power Station more (i.e. in winter) results in the lowering of Lake Gordon which causes a loss of efficiency at Gordon Power Station (i.e. through loss of head). This efficiency loss is compounded as more water is required to generate the same energy which further reduces the lake level and thus increases the efficiency loss. The loss of Basslink revenue can be attributed to the lower lake level, as when the Gordon Power Station is operated at its maximum flow the loss of efficiency transfers directly into a lower power output and lost Basslink revenue.

Table 3.14 Annual Costs to Hydro Tasmania of a Gordon River Minimum Environmental Flow

Delivery Mechanisms	**No power generation**		**Efficient load 1-generator**		**Half load 1-generator**		**Exact power generation**	
Target Flow in Range	Middle	Bottom	Middle	Bottom	Middle	Bottom	Middle	Bottom
Flow in Cumecs	23 summer 43.5 winter	19 summer 38 winter	23 summer 43.5 winter	19 summer 38 winter	23 summer 43.5 winter	19 summer 38 winter	23 summer 43.5 winter	19 summer 38 winter
Cost ($M) in Lost Basslink Revenue	1.8	not assessed	1.4	1.2	0.8	0.8	0.7	0.7
Cost ($M) in Reduced EIS	0.3	not assessed	1	1	0.7	0.6	0.5	0.4
TOTAL COST ($M/yr)	**2.1**	**not assessed**	**2.4**	**2.2**	**1.5**	**1.4**	**1.2**	**1.1**

Target environmental flows are expressed as a range in Table 3.13, but the Hydro Tasmania system operators require a single flow target. Consequently, costs in Table 3.14 were derived for a flow target within the middle of the identified winter and summer ranges in Table 3.13, and at the bottom of these ranges.

Power generation is most efficient if it occurs at the individual generator's efficient load, so to generate at very small flows can be inefficient in terms of energy gained for water discharged. Table 3.14 shows, however, that the most cost-effective approach is to generate exactly the flow required, despite the inefficiencies on the generators.

It is also most cost effective to target the flows at the bottom of risk band II rather in the centre of this band. This approach results in a cost requirement on the part of Hydro Tasmania of between $1-2 million per annum, in terms of lost Basslink revenue and reduced energy in storage (EIS).

3.9.5.3 Hydro Tasmania Commitment to a Minimum Environmental Flow

The outcome of this analysis of costs and benefits of a minimum environmental flow, is a commitment by Hydro Tasmania to maintain a minimum environmental flow of 19 m^3/s between December-May, and 38 m^3/s between June-November, just upstream of the Denison River as part of the environmental mitigation package for the Basslink development. This is a substantial environmental flow commitment, believed to be the largest environmental flow in Australia. A significant benefit of Basslink is that it provides the financial opportunity for Hydro Tasmania to commit to such a significant mitigation measure.

Details of the commitment include that:

- The minimum flow be phased to allow adequate monitoring of environmental benefit and understanding of environmental response to progressively increasing minimum environmental flows. It is specifically proposed to initially maintain flow targets of 10 m^3/s between December and May, and 20 m^3/s between June and November upstream of the Denison River for the first three years after Basslink commences. The target minimum flows would then be increased to the 19-38 m^3/s targets for the next three years. This would allow an assessment of the sensitivity of the instream biota to the minimum environmental flow.

- The minimum environmental flow targets be lowered proportionately if inflows to Lake Gordon are less than the flow targets. The rationale for this is that the minimum environmental flow is based on average minimum flows, and the river under pre-dam conditions would experience flows lower than these during dry years.

The Basslink development would be accompanied by a significant monitoring package in the Gordon River (see Section 3.10), and this is seen as an excellent opportunity to further the understanding of the environmental benefits of a minimum environmental flow.

3.9.5.4 Risks with Ability to Deliver Flow Via the Power Station

The preferred method of providing the environmental flow into the Gordon River is by passing water through the generators in Gordon Power Station. However there are some events that will prevent this occurring. These events fit into two broad categories, being forced and scheduled outages. The forced outages relate to unplanned failure of equipment or systems that cause all generators to shut down and stop the water flow whereas the scheduled outages relate to programmed maintenance work, particularly with the intake and tailrace.

The causes of a forced station outage include transmission line failure (both lines), intake gate or intake shaft problems, switchyard equipment failures, station fire or flood, or tailrace problems.

The power system fault statistics for the generators and the transmission system for the last 15 years were examined to determine the underlying frequency and duration of faults that would have caused all of the generators to be shut down. This category of outages will vary with the age and condition of the equipment, the way it is used and the prevailing weather and operating conditions. Similarly the statistics for the scheduled outages have been provided by the operations staff in general terms including a schedule of planned future outages.

An analysis of statistics derived from station fault reports provided by Hydro Tasmania's Protection Design Department shows that the Gordon Power Station is very reliable with only infrequent events that caused both transmission lines or all generators to trip. Over the past 15 years, there were years with no outages and other years with outages of mostly very modest duration. Most forced outages have been less than 6 hours duration, and only one outage over the past 15 years has lasted more than 24 hours. It appears rare to have more than two forced outages in a year.

Routine scheduled outages for the Gordon Power Station normally consist of;

- At least four single working day intake gate outages per year, to inspect gate seals and do essential maintenance.
- Routine black start testing requires two half-day outages per year.
- Every 6-8 years, there will be an extended 6 week outage of the intake gate for major maintenance and testing. The outage is generally in winter.
- There will be other irregular outages scheduled for specific works or projects. Normally these would be of short duration, and/or affect only one generator and not the whole station.

The operational history shows that in an average year there may be two forced outages of up to 6 hours duration, and there will be six scheduled complete station outages of up to 8 hours duration when water will not be discharged from the power station.

The only likely large time gap in the flow discharge is for the major maintenance and testing of the intake gate, which will occur approximately every 6-8 years and can be scheduled in winter to ensure minimal risk to the downstream biota.

3.9.6 Measures such as Power Station Ramp-Downs or Step-Downs to Address Seepage-Induced Erosion

Power station ramp-downs were identified by a number of the researchers (Section 3.9.3). The instream biota study identified a full power station ramp-down as beneficial for macroinvertebrates. However, because it would need to be as slow as natural ramp-down rates (days to weeks) to provide this benefit, it was not recommended as a Basslink mitigation option because of its fundamental incompatibility with the Gordon Power Station operations. The fish study identified a partial or stepped ramp-down as potentially beneficial, as it could provide cues to the fish of dropping flows before full dewatering of habitats occurred, hence reducing the potential for stranding under Basslink. Full ramping of the power station discharges was not recommended by the fish researchers, as it would result in increased durations of high discharge which would prolong restrictions in habitat availability and would limit upstream migration opportunities for fish.

The major area which is identified to benefit from a ramp-down rule or some comparable measure is fluvial geomorphology. Scour and seepage-induced erosion are the main processes causing destabilisation of devegetated riverbanks in the Middle Gordon River (Section 3.3.3.10). The highest risk of seepage-induced erosion was found to occur under conditions where the banks were fully saturated (research showed this to occur after prolonged full gate power station operation, although heavy rainfall conditions could also create this condition), followed by a complete shutdown of the power station. Under these conditions, a very steep phreatic surface gradient was present in the riverbanks. Field observations during the Basslink investigations showed consistently that under these conditions the banks were most unstable.

Some benefit in lessening processes leading to riverbank instability is provided by the Hydro Tasmania commitment to a minimum environmental flow as part of a Basslink mitigation package. A minimum environmental flow reduces the potential for erosion due to scour (by reducing the water surface slope when the power station turns on) as well as seepage (by reducing the phreatic surface gradient in the riverbanks).

A minimum environmental flow accompanied by a ramp-down requirement or other comparable measure provides even further potential to reduce phreatic surface gradient in the Middle Gordon River banks, and thus seepage-induced erosion events.

Figure 3.18 shows phreatic surface gradients in a riverbank upstream of the Splits immediately following power station shutdown. The data plotted in Figure 3.18 was collected from piezometers located at Site 70.6 on 17 March 2000. The conditions prior to 17 March 2000 had created fully saturated riverbanks, such as occurs under existing power station operating patterns that may have the Gordon Power Station discharging continuously at full gate for months (and observed during the 1999-2000 summer period). The site location corresponds to a reach of the river where some of the greatest changes in water level occur in response to power station operations, so Figure 3.18 is representative of the maximum height of bank saturation leading to seepage-induced erosion. The thick black line is the riverbank profile. The red line shows the water surface in the river and the phreatic surface gradient in the banks when the power station turned off. The coloured lines consecutively below the red line show the change in phreatic surface gradient at one hour time intervals following power station shutdown. Apparent from this figure is that there is very little change in phreatic surface gradient in the first two hours following power station shutdown, but in the third hour there is a significant increase in phreatic surface gradient which is maintained for the next five hours.

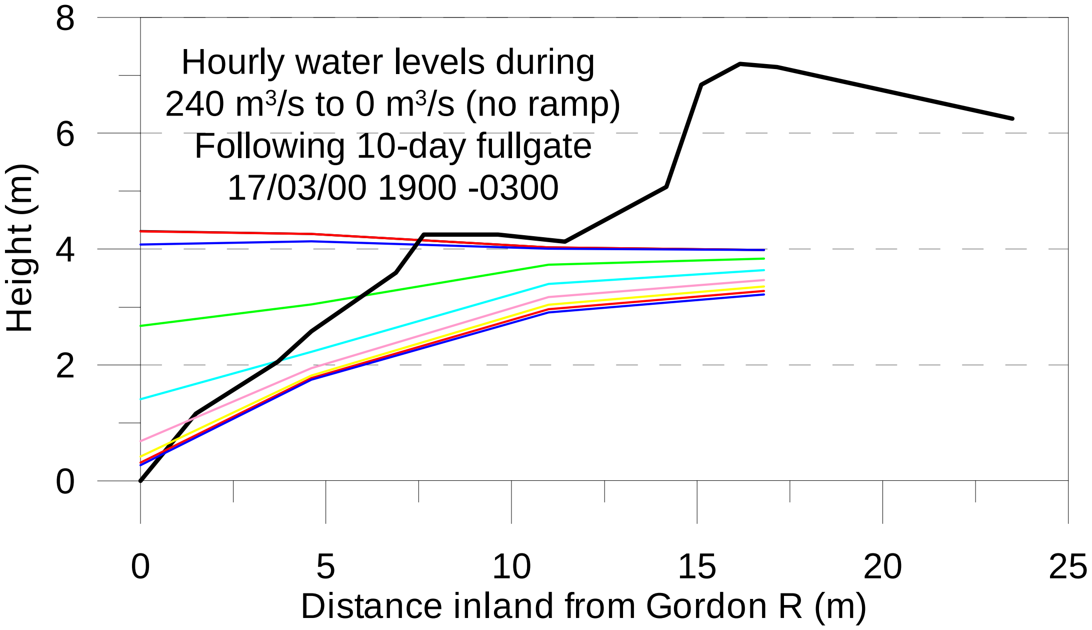


Figure 3.18 Phreatic Surface Gradients Following Complete Power Station Shutdown with Fully Saturated Riverbanks

A comparison can be made with Figure 3.19, which shows a similar sort of plot at Site 70.6 showing data obtained on 19 August 2000. Prior to 19 August 2000, the power station was run for 24 hours at full gate, preceded by 10 days of 1 or 2 turbine use which resulted in partially saturated banks. Apparent from this figure is that in the first two hours following power station shutdown, the riverbanks are actually still filling with water, due to the elevated river levels created by the most recent (but short-duration) power station full gate discharges. The maximum phreatic surface gradients do not occur until the fourth hour, they are less steep than those shown in Figure 3.19, and they occur at a lower elevation in the river bank than those shown in Figure 3.19.

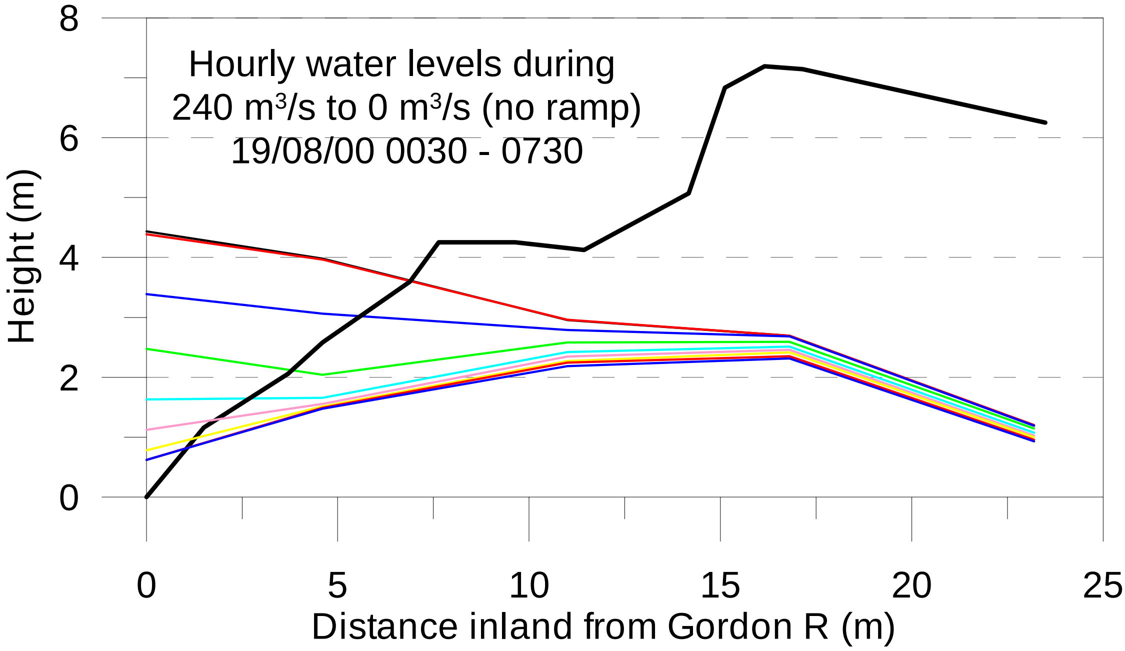


Figure 3.19. Phreatic Surface Gradients Following Complete Power Station Shutdown with Partially Saturated Riverbanks

The piezometer data provide a very good means of assessing the response of the phreatic surface gradients in the Gordon riverbanks to changes in river water level. It is apparent that changes could be implemented in the rates and pattern of power station shutdowns (i.e. a ramp-down or comparable rule) that would alter the phreatic surface gradients in the Middle Gordon River banks, with the intention of improving stability of the banks. Because of the identified disadvantages of a full power station ramp down rule (e.g. maintains too high flows for too long, can continue to “fill” the riverbanks), a rule which requires ramp-down or step-down within part of the power station discharge range may be more appropriate.

Hydro Tasmania is committed to implementation of a mitigation measure to minimise seepage-induced erosion of the Middle Gordon riverbanks, such as a ramp-down or step-down rule for the Gordon Power Station. An example of a potential power station operating rule which is receiving close consideration is the ‘210-150’ rule, which requires the power station to step down from discharges greater than 210 m^3/s to 150 m^3/s for one hour before shutting down, with the aim of allowing drainage of the upper portion of the bank and reducing draw-down rates. Hydro Tasmania is committed to an experimental approach to development of a mitigation measure that is both environmentally and economically sustainable. To support this assessment, Hydro Tasmania is committed to installation of robust long-term piezometer sites and development of a riverbank saturation-phreatic surface gradient model to test seepage response to different scenarios.

The experimental program to which Hydro Tasmania commits is currently in progress. Its aims are to identify seepage slope conditions associated with onset of sediment flows, and then to identify and test mitigation options to minimise seepage-induced erosion. The first phase involves upgrades of piezometer instrumentation and installation of a rain gauge in the Middle Gordon River, and then observations of the onset of sediment flows during power station shutdown after differing power station operational patterns. Dedicated power station simulations will be conducted to assist this program.

A measure such as a partial ramp-down rule, in combination with maintenance of a minimum environmental flow, comprises a mitigation package consistent with best-practice approaches to river improvement measures. This package not only significantly addresses Basslink environmental impacts of the Gordon Power Station, but also has significant potential to improve the existing environmental condition of the Middle Gordon River.

3.9.7 Hydro Tasmania Basslink Commitments for the Gordon River

Hydro Tasmania is committed to implementation of the following mitigation measures if the Basslink project is approved:

- Maintenance of a minimum environmental flow in the Gordon River of 19 m^3/s between December-May, and 38 m^3/s between June-November, measured just upstream of the Denison River. Minimum flow targets will be lowered proportionately if inflows to Lake Gordon are lower, because the flow targets of 19 and 38 m^3/s are based on average pre-dam minimum flows, and the river under pre-dam conditions would experience flows lower than these during dry years. This minimum flow will be phased in over a period of years, to allow adequate monitoring of environmental benefit and understanding of environmental response to progressively increasing minimum environmental flows. A minimum environmental flow will improve conditions for the instream macroinvertebrate biota, by ensuring watering of the ‘mid-tidal’ zone and inundation of marginal snag habitats. It would also result in increased habitat for fish, improved food supply (macroinvertebrates) for fish and platypus, and be beneficial for the fluvial geomorphology by lessening scour of the bank toe and reduce phreatic surface gradient out of the banks. This measure is costed at $1.2 million in losses per annum to Hydro Tasmania.

- Implementation of a mitigation measure to minimise seepage-induced erosion of the Middle Gordon riverbanks, such as a ramp-down or step-down rule for the Gordon Power Station. An example of a potential power station operating rule which is receiving close consideration is the ‘210-150’ rule, which requires the power station to step down from discharges greater than 210 m^3/s to 150 m^3/s for one hour before shutting down, with the aim of allowing drainage of the upper portion of the bank and reducing draw-down rates. Hydro Tasmania is committed to an experimental approach to development of a mitigation measure that is both environmentally and economically sustainable. To support this assessment, Hydro Tasmania is committed to installation of robust long-term piezometer sites and development of a riverbank saturation-phreatic surface gradient model to test seepage response to different scenarios.

The effectiveness of these measures will be assessed via an environmental monitoring program, which in itself is a major benefit of Basslink. Hydro Tasmania is committed to an adaptive management approach in responding to information obtained through the monitoring program, so that mitigation measures can be re-assessed and fine-tuned over time to ensure that they are environmentally and economically sustainable.

This is believed to be a well-rounded mitigation package. It not only significantly addresses potential Basslink environmental impacts of the Gordon Power Station, but also has significant potential to improve the existing environmental condition of the Middle Gordon River. Because of its focus on water management as a river management tool, it is in keeping with the World Heritage Area objectives for the Gordon River. Water management commitments such as proposed here can be incorporated into the Hydro Tasmania Water Licence and so be regulated under the Tasmanian *Water Management Act* 1999.

The following section describes the proposed program which is considered an integral part of the Gordon River mitigation package.

3.10 Gordon Basslink Monitoring

3.10.1 Overview

A considerable number of monitoring sites were established in the Gordon River catchment for the purposes of the Basslink investigations in 1999-2000. These are identified in this report. Figure 3.5 lists the present and historical sites for hydrological monitoring. Map 3.5 shows the zones established for geomorphic investigation. Map 3.6 shows the karst areas in the middle Gordon catchment. Map 3.7 and Map 3.8 show the sampling sites for macroinvertebrate studies; and Map 3.9 shows the locations of the zones established for fish monitoring.

This section considers what monitoring activities will continue to be undertaken if the Basslink project is approved. The purpose of the program is to monitor the existing conditions within the Gordon River; indicate the range of inter-annual variability; assess the changes (short- or long-term) caused by Basslink operations; and determine the effectiveness of any mitigation measures applied.

Access is a major issue. Any on-site monitoring activity will require helicopter support and power station shut-down. Due to the density of the terrestrial vegetation and the absence of access infrastructure in this wilderness area, the only effective way to reach the sampling sites is by helicopter, and the only viable landing sites are on cobble bars in the river bed which are only exposed when the power station is shut down.

For Hydro Tasmania's Basslink environmental investigation program, Gordon Power Station shut downs were requested. It is proposed that the Gordon Basslink Monitoring Program will revolve around a schedule of three visits per year, involving two consecutive days of power station shut down. These would occur on weekends when load requirements from the power station were lowest. For these six days of the year, the minimum environmental flow proposed in Section 3.9 would not be able to be delivered, in order to facilitate helicopter landings on the river bed.

Weather is a major logistical constraint in south-west Tasmania and some flexibility will need to be accepted with the planned visits. If access is impossible on the planned shut down weekends, the 'outage' for the Gordon Power Station will be postponed to the following weekend.

The following sections list, firstly, the proposed monitoring program and, secondly, provide a discussion of possible future studies.

3.10.2 Gordon Basslink Monitoring Program

The Gordon Basslink Monitoring Program, which is a key part of the Basslink mitigation package for the Gordon River, includes elements of water quality, fluvial geomorphology, karst geomorphology, riparian vegetation, macroinvertebrates, algae, fish, and cave biota. The details of the proposed monitoring can be found in the relevant appendices, and summaries of the researchers' recommendations for monitoring have been provided in this report in the sections noted below.

The proposed program includes a comprehensive on-site field component operating over nine years (three years pre- and six years post-Basslink). The first year of this program is the 2000 investigative year. The duration of six years post-Basslink permits monitoring of the influence of the minimum environmental flow, which is set for 10/20 m^3/s (summer/winter) during the first three years post-Basslink, and 19/38 m^3/s for the next three years. This staged approach is taking advantage of the enormous research opportunity presented with Basslink to assess the response of the Gordon River to the minimum environmental flow as a major remediation measure. Aerial photography will be conducted over a longer time-period, with the last assessment conducted ten years post-Basslink.

Additional data collection and analysis will be available to this program from existing monitoring facilities, which will continue alongside the Basslink monitoring program.

The timing of the field-based monitoring activities will be closely coordinated so that the required work can be completed during the necessary power station shut downs.

Almost all of the elements to be monitored will rely on accurate hydrological data for analysis of monitoring results. It will be necessary to retain the existing permanent hydrological monitoring stations, and the recently installed temporary stations should be maintained for the duration of the major elements of the monitoring program.

Most of the suggested **water quality** monitoring (see Section 3.2.2.4.3) is presently being carried out under the Waterway Health Monitoring Program. The principal requirement of the Gordon Basslink Monitoring Program is to ensure that this monitoring is continued for at least six years.

Additionally, an assessment of the occurrence of supersaturated conditions will be incorporated into the program. If this analysis indicates that the incidence or magnitude of oxygen supersaturation has increased under Basslink, then a program of more extensive monitoring of gas saturation levels will be developed and implemented, guided by the findings presented in the water quality report (Appendix 3 of this report series).

The **fluvial geomorphology** monitoring will require aerial photography of the Middle Gordon River, including the lower Albert River and the mouths of other tributaries, repeated at 3, 6 and 10 years post-Basslink.

Fluvial geomorphology field-based monitoring (see Section 3.3.7.1) will be conducted for three years pre- and six years post-Basslink. It will include measurements of:

- bank erosion (erosion pins, scour chains and photo monitoring), including the establishment of new monitoring sites;
- photo monitoring of cobble bars; and
- continued monitoring of water movement in the banks (piezometers and river level recorders), including establishment of a new site in Zone 2.

In terms of **karst geomorphology** (see Section 3.4.5), the erosion pins in Bill Neilson Cave and Kayak Kavern will be monitored. Additionally, in conjunction with the cave biota monitoring, a visual inspection of the usually dry parts of the cave will be carried out, to indicate if unusually high water levels have occurred. If this is the case, then a more focussed research program investigating the potential effects will be instituted, guided by the suggestions in Appendix 5 of this report series.

Riparian vegetation monitoring (see Section 3.5.2.5), replicating the present study, will be carried out at three and six years post-Basslink.

A nine-year monitoring program for **macroinvertebrates** and **algae**, as detailed in Section 3.5.3.5, and Appendix 7, will be undertaken, with sampling activity timed for October and April (spring and autumn) each year.

A nine-year, comprehensive **fish** monitoring program, as detailed in Section 3.5.4.8 and Appendix 8, will be undertaken with sampling activity timed for January and April (summer and autumn) each year.

The Gordon Basslink Monitoring Program will, necessarily, require on-site visits by monitoring and / or maintenance staff to the various sampling sites in the middle Gordon. Such activities will require a power station shut down of sufficient duration and timing to facilitate completion of all the scheduled work.

The Gordon Basslink Monitoring Program will form by far the most substantial part of the overall Basslink Monitoring Program. The annual cost of the proposed program will be in the order of $257,000, of which $90,000 will be required to cover 9 days of helicopter use (two days in Gordon River, one day in tributaries for control comparisons each visit). The high access costs (helicopter plus station shut down) and short timeframe for each visit will mean that the monitoring activities will need to be tightly managed, with limited numbers of participants.

A report summarising monitoring activities and findings will be produced and submitted to DPIWE on an annual basis.

Table 3.15 lists the approximate schedule and activities required for each visit, for each monitoring element.

Table 3.15 Summary Gordon Basslink Monitoring Program Activities

Element	**Parameter**	**Location**	**Frequency**	**Timing**	**Notes**
Hydrology	stage height	PS tailrace, Gordon sites 75,72,69,65,62,47 and 39	continuous	Oct Dec, Apr,	downloading non-telemetered sites
Water Quality	Water temperature, dissolved oxygen	PS tailrace	continuous	n/a	additional analysis required; may need additional resources to monitor temperature probes downstream of dam.
	Gas supersaturation	various Gordon sites	as required		only required if d.o. analysis shows an increase in oxygen supersaturation post-Basslink.
Fluvial Geomorph.	aerial photog.	length of river, including lower Albert & trib. mouths	3,6 & 10 years post-Basslink	PS shut-down	need to verify if this freq is most suitable
	bank erosion, photo monitoring, piezometers	Zones 1-5	bi-annually for next year	Oct, Apr	Revise monitoring program after another year of data collection
Karst Geomorph	erosion pins, visual inspection	Bill Neilson Cave, Kayak Kavern, doline area	bi-annually	Oct, Apr	link with fluvial geomorph. monitoring
	water level	Gordon site 62	continuous	service intervals	only required if visual inspection indicates Basslink related high water levels in cave
Riparian Vegetation	presence / absence	Zones 1-5	Basslink +3, & +6 yrs	Dec	compare with results of present study
Macroinverts	AUSRIVAS protocol	Gordon sites 75, 72, 69, 63, 60, 58, 46 & 42. Reference sites Ja7, Fr11, Fr21, De7, De35 & UG10	twice per annum	Oct & April	
algae	spp & cover	Gordon sites 75, 72, 69, 63, 60, 58 & 42.	twice per annum	Oct & April	
fish	spp, distribution, CPUE	Zones 1-5 (15 sites) + tribs (16 sites) & reference sites (11 sites)	twice per annum	Dec & April	see tables 9 & 10 in Fish Report (Appendix 8)

3.10.3 Further Studies

A number of researchers flagged areas of research which may provide valuable information about operational effects and related processes. These are listed in Sections 3.3.7.3 and 3.5.2.5.3. These research areas are beyond the scope of the Basslink Monitoring Program, but the opportunities for access presented by the monitoring program may facilitate investigation into some of them.

3.11 Conclusions from Gordon Investigations

The Gordon River investigations for the Basslink development have provided considerable data documenting modifications to the riverine channel and ecosystems due to existing power station operations, particularly upstream of the Denison River. The Basslink development alters the historical operating patterns of the Gordon Power Station, which in turn will result in further adjustments to the Middle Gordon River channel, most particularly upstream of the Denison River.

Basslink changes to the Gordon River, in the absence of the substantial mitigation measures to which Hydro Tasmania commits, are anticipated to cause further degradation to instream biota (macroinvertebrates, fish) and condition of the riparian zone (riverbank stability, riparian vegetation community structure), particularly upstream of the Splits. As a consequence of the understanding of environmental processes obtained from these investigations, the Basslink project will be accompanied by two key riverine enhancement measures for the Gordon River, and a substantial monitoring program.

The provision of a minimum environmental flow and implementation of a measure such as a partial ramp-down or step-down rule represent major measures on the part of Hydro Tasmania to substantially mitigate not only Basslink impacts, but also improve existing environmental conditions in the Middle Gordon River. These measures are at a significant cost to the business, totalling more than $1.2 million in losses to the business each year.

Basslink operation of the Gordon Power Station accompanied by an environmental flow and a measure such as a partial ramp-down or step-down rule is anticipated to, at a minimum, maintain present trends in the condition of the riparian zone and instream biological communities. The Basslink development even in the absence of mitigation measures does provide benefits in terms of reducing the risk of water with low dissolved oxygen levels being discharged into the Middle Gordon River, and increasing opportunities for fish migration and platypus dispersal.

The Basslink development will be accompanied by a comprehensive and broad-ranging monitoring program. This program has been costed at $257,000 per year, making Hydro Tasmania's environmental commitment to the Gordon River greater than $1.5 million per year. There is potential, through long-term information gained from this monitoring program, to increase understanding of responses to regulated flow conditions to a point where mitigation measures can be refined and optimised from both an environmental and economic perspective.

These are substantial financial commitments on the part of Hydro Tasmania, and can only be made because the Basslink development provides the financial framework for the business to make such commitments.

The JAP requires the Basslink IIAS to assess whether there is sufficient baseline data to assess the impact of Basslink on the TWWHA. These investigations have provided very good insights into the present state of the Middle Gordon River, and have identified the types and extent of changes that are anticipated to occur with Basslink operation of the Gordon Power Station. This information is considered sufficient to assess the impact of Basslink on the TWWHA, and to identify the most beneficial mitigation measures to accompany the Basslink development. Additional information is unlikely to change the conclusions, but rather allow refinement of theories and more precise quantification of spatial and temporal variability, processes and rates.

The Basslink project accompanied by the Hydro Tasmania commitments presents an opportunity to improve environmental management and sustainability of the Gordon River, because it provides the financial framework for Hydro Tasmania to implement major riverine enhancement measures. Hydro Tasmania's monitoring commitment will enable assessment of the success of the mitigation measures, and further increases in understanding of key processes so that refinements to these measures can be undertaken if required in the future.

4 DOWNSTREAM POATINA POWER STATION INVESTIGATIONS

Section 4 begins with background information on the Great Lake – South Esk catchment area and the Poatina Power Scheme (Section 4.1).

Sections 4.2 to 4.7 present the outcomes of the environmental assessment of Basslink impacts on each of the major headers required for assessment in the Basslink Integrated Impact Assessment Statement:

Sec.4.2 - Surface Waters (hydrology, flooding, water quality),

Sec.4.3 - Land (fluvial geomorphology),

Sec.4.4 - Groundwater,

Sec.4.5 - Flora and Fauna (instream biota, terrestrial biota),

Sec.4.6 - Estuarine Issues, and

Sec.4.7 - Socio-Economic Issues (cultural heritage, visual amenity, public use and safety, industries affected and economic impacts).

Section 4.8 summarises the investigations downstream of the Poatina Power Station, identifies Basslink issues, and proposes mitigation options.

Section 4.9 presents the proposed Basslink monitoring program for downstream of Poatina Power Station.

4.1 Background Information on Catchment

4.1.1 Catchment Characteristics

The Poatina Power Development utilises water out of Great Lake catchment, located in the Central Plateau region of Tasmania, and discharges it into the South Esk catchment which is located in the north-east and midlands of Tasmania (Map 4.1). The South Esk catchment is the largest water catchment in Tasmania, covering an area of approximately 8,900 km^2, or 15% of Tasmania’s land area. Poatina Power Station discharges into Brumbys Creek, which is a tributary of the Macquarie River, which in turn flows into the lower South Esk River, which in turn flows into Lake Trevallyn in Launceston and ultimately the Tamar Estuary

The principal uses of the Great Lake catchment are for hydro-electric power generation, fishing, and shack settlements primarily associated with fishing and recreation. The primary land use in the South Esk catchment downstream of Poatina Power Station is agriculture. There are two townships in the part of the catchment downstream of Poatina, Cressy and Longford. There is also an irrigation scheme (the Cressy-Longford Irrigation Scheme), an aquaculture industry on Brumbys Creek (Sevrup), and an agricultural research station (Cressy Research Station). The waterways downstream of Poatina are also utilised for fishing and recreational boating.

Jurassic dolerite dominates the Great Lake catchment and the western part of the Macquarie River sub-catchment of the South Esk basin, forming the cap of the Central Plateau and the Great Western Tiers. The lower South Esk catchment is characterised by the flat, undulating valleys of the Launceston Tertiary Basin, which is made up of alluvial gravels, sand and till. The lowland areas are typically low relief hills with relict terraces and flood plains.

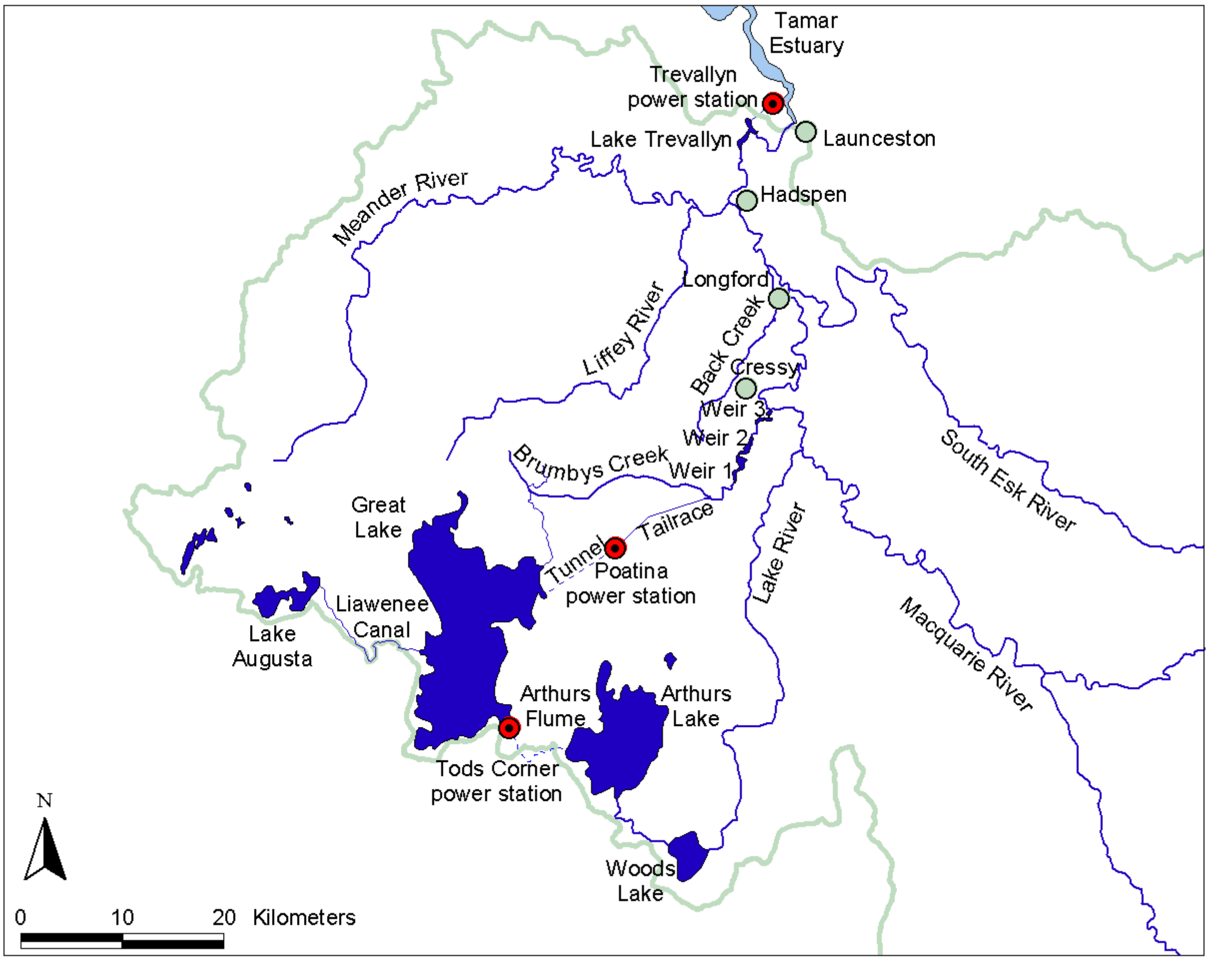
Alpine vegetation and grasslands are found on the Central Plateau, with the distribution varying depending on local climatic influences and human activities. Most of the natural vegetation in the South Esk catchment has been cleared for agriculture, and the land is now used primarily for grazing or cropping.

The Great Lake catchment has variable precipitation ranging from 2000 mm annually in the west to 800 mm annually in the southeast, with snow accounting for up to 30% of precipitation. Rainfall in the South Esk basin is also variable, ranging from 510 mm annually at Ross to 1200 mm annually at Gray on the eastern side of the catchment. The Macquarie sub-catchment is drought-prone, with large areas receiving less than 600 mm of annual rainfall.

4.1.2 Poatina Power Scheme

The Poatina Power Scheme utilises water from the Great Lake catchment, as well as diversions into Great Lake from Arthurs Lake, Lake Augusta, and several small weirs (see Map 4.1). The main storage for the scheme is Great Lake, supplemented by Lake Augusta and Arthurs Lake. The two power stations in the scheme are Poatina Power Station and Tods Corner Power Station. Tods Corner plays a limited role, built to take advantage of the fall of water down to Great Lake after being pumped up from Arthurs Lake – the long-term average power output from the station is 1.0 MW.

The Poatina Power Scheme is most notable for the diversion of Great Lake water from the Derwent catchment via the Poatina Power Station to the South Esk catchment. This diversion takes advantage of the 835m head down the face of the Great Western Tiers, thus increasing the energy value of Great Lake water compared with the alternative route for this water down the Derwent system. The Great Lake storage has a surface area of 176 km^2 at full supply level, a reservoir volume of 3,179 Mm^3, and an approximate depth of 25 m at the Miena Dam. The lake has an operating range of 21 m, and an intake located 23 m below full supply level.



Map 4.1 Great Lake/South Esk catchment.

The Poatina Power Station is the second largest in Tasmania. The power station is underground, and houses six 60 MW Pelton generators. The long-term average power output from the station is 137.3 MW. Water from Poatina is discharged via a 4.4 km tailrace tunnel into a 6.1 km tailrace canal which flows into Brumbys Creek.

Similar to the Gordon Power Station, Poatina is most commonly operated to provide ‘base load’ or ‘step load’. During the relatively dry summer period, the Poatina Power Station runs as a base load station, with the number of generators in use depending on the daily electricity demand. At other times of the year, Poatina operates on step load, and generators are brought on or off depending on the changing electricity demand throughout the day.

Efficient load for all six generators at the Poatina Power Station equates to a power station discharge of approximately 32 m^3/s, and full capacity discharge is approximately 52 m^3/s. Efficient load and full capacity discharge varies slightly depending on water levels in Great Lake.

All water from the South Esk catchment flows through Lake Trevallyn, and is either utilised by the Trevallyn Power Station or spills over Trevallyn Dam to reach the Tamar Estuary. The Trevallyn Power Station is located only 5 km from Launceston, has very little storage (12 Mm^3), and utilises the daily flows down the South Esk River. The four generators at this station have a combined capacity of 83.6 MW, and the long-term average power output is 57.5 MW.

The two power stations in the Poatina Power Scheme (Tods Corner and Poatina) provide 12.5% of Tasmania’s long-term average power output, and Trevallyn Power Station makes up 5.0%.

4.2 Environmental Assessment of Surface Water Impacts

This section looks at environmental information on the hydrology and water quality downstream of the Poatina power station, in relation to present status and potential Basslink changes.

4.2.1 Hydrology

A summary of hydrological information on historical Poatina Power Station operations and predicted Basslink changes is provided as Appendix 15.

4.2.1.1 Lake Levels

The historical record for Great Lake extends back as far as 1916 but for the plots below, the record has been taken from 1964 when the Poatina Power Station first commenced operation. Figure 4.1 reveals extensive variations in historical lake levels over the 34-year period. Basslink tends to level out these variations with reductions in peak levels and increases when the historical level drops significantly. In general, the lake levels under Basslink are lower than the corresponding historical levels.

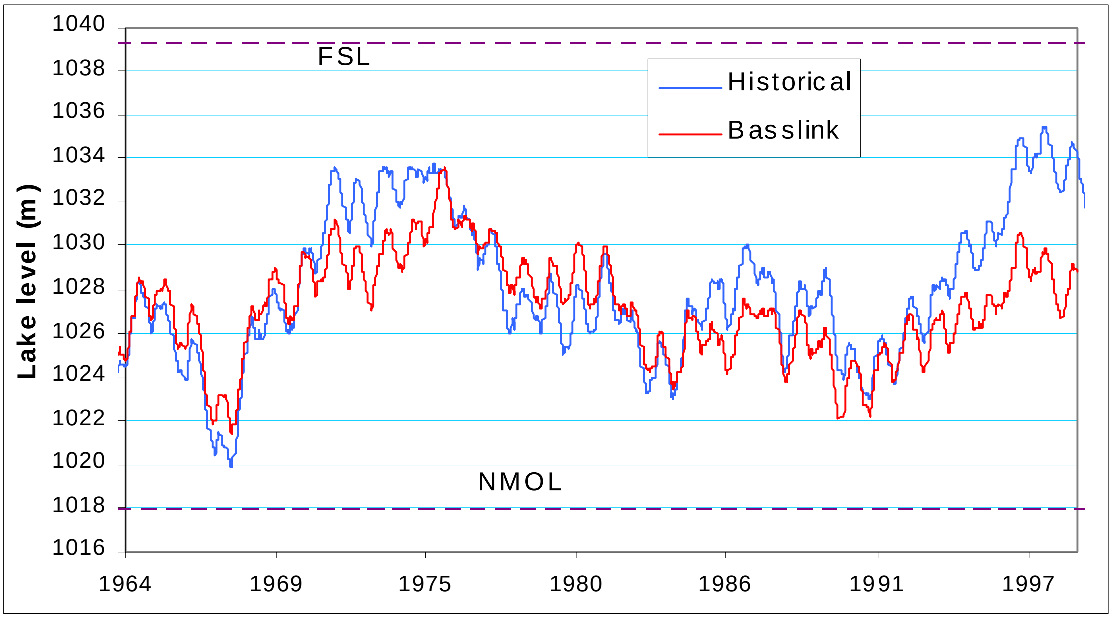


Figure 4.1 Lake Level Time-Series Plot fot Great Lake

From the duration curve (Figure 4.2) it can be seen that when the lake level approaches FSL, Basslink tends to draw the Great Lake storage down. As the level reduces the load reduces, and the duration curve for Basslink approaches the duration curve of the historical data. This suggests that under Basslink, the storage at Great Lake will be used more efficiently compared with historical use. The seasonality of lake levels under Basslink (Figure 4.3) remains similar to the historical pattern.

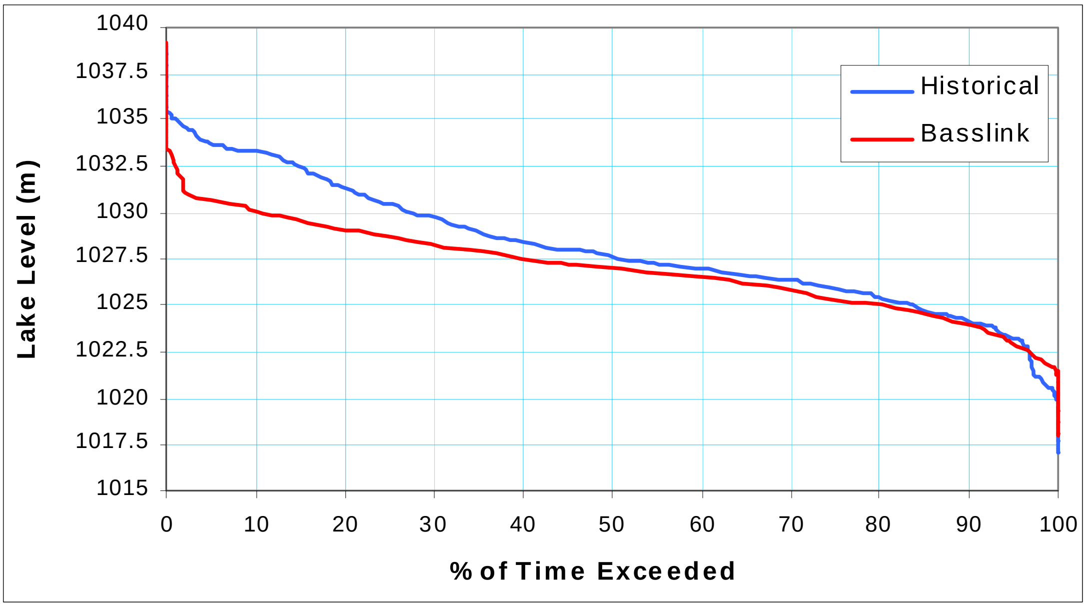


Figure 4.2 Lake Level Duration Plot for Great Lake

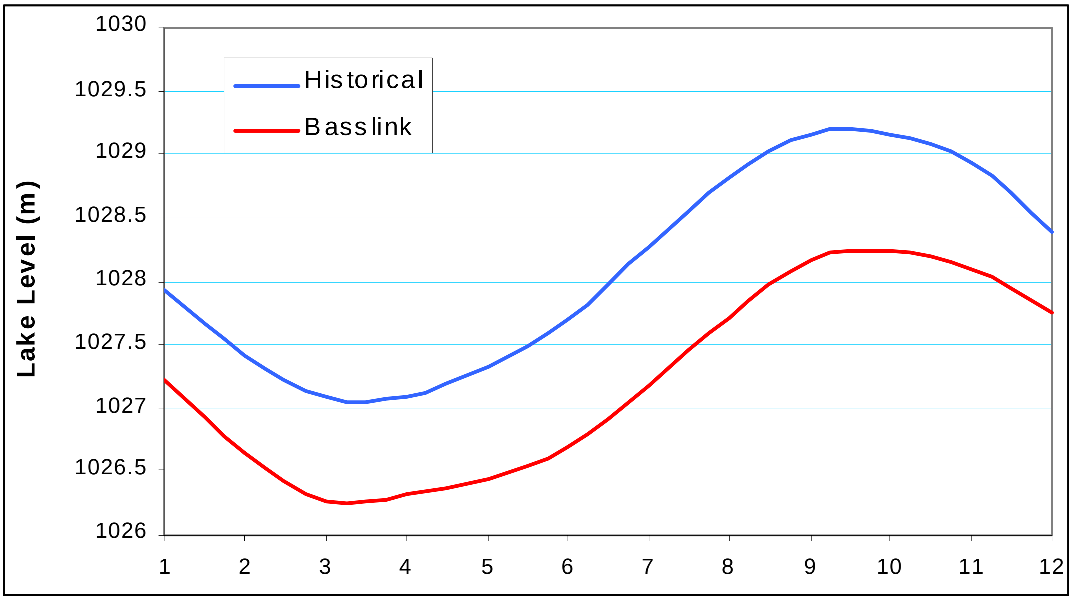


Figure 4.3 Average Monthly Lake Levels for Great Lake

Figure 4.4 shows that there is a slight reduction in the range of Lake Gordon levels under Basslink, with the 10th percentile level slightly lower and the 90th percentile level slightly higher than in the historical case.

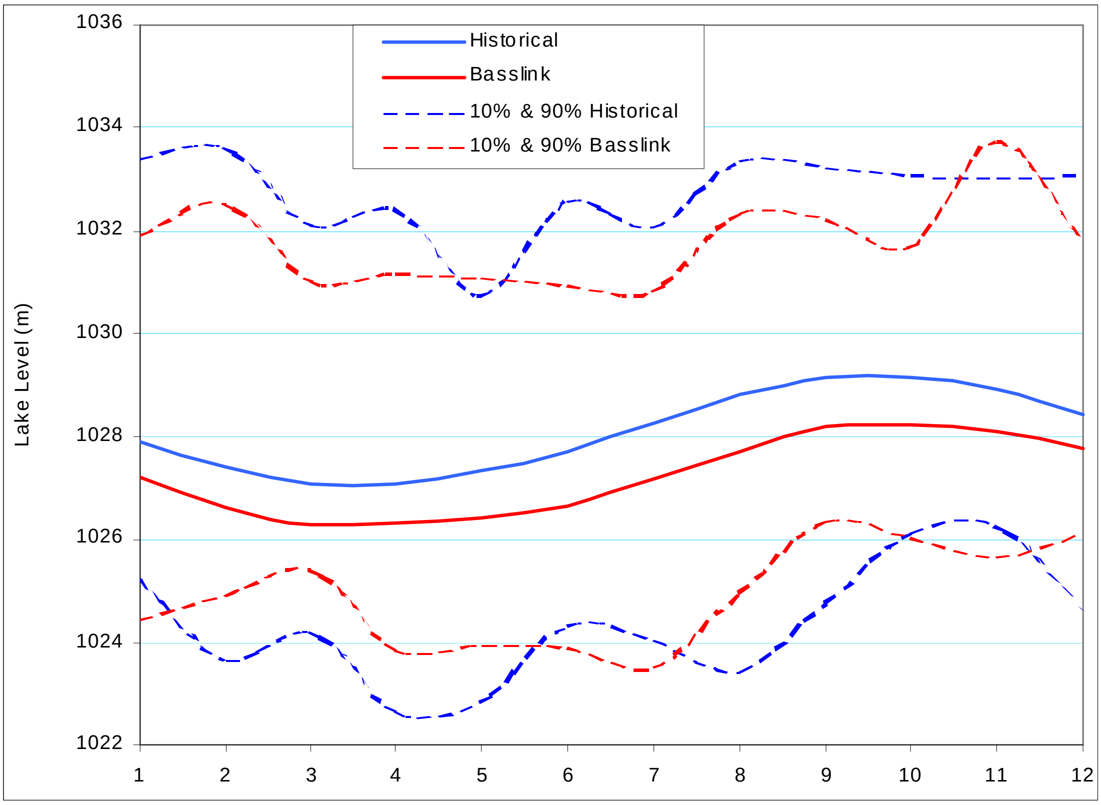


Figure 4.4 Mean, 10th and 90th percentiles of Great Lake level under Historical and Basslink scenarios

4.2.1.2 Power Station Discharges

Operation of the Poatina Power Station varies considerably between a wet year and a dry year. During a wet year much of the electricity demand can be met by the run-of-river stations rather than by the Poatina Power Station, so Great Lake accumulates water. Figure 4.5 shows time series plots using daily data for the Poatina Power Station during a dry year (1989) and a wet year (1964) for historical operations and Basslink. Caution must be taken when examining these plots, as the system configuration and load changed between 1964 and 1989.

The main differences between the historical and Basslink scenarios as indicated in the time series plots can be summarised as follows:

- Historically, there is more generation from Poatina during the dry year than the wet year. Under Basslink, there is power station generation throughout the year for both dry and wet years.
- Basslink results in increased on-off operation of the power station in both a wet year and a dry year.
- During a wet year, there is an increase in full capacity discharge from the power station with Basslink compared to historical.
- Basslink tends to increase the occurrence of weekend shutdowns of the power station.

Basslink will not cause larger than historical maximum releases from the power station, because the magnitude of the release is limited by the capacity of the six generators. Rates of river level rise and fall will not change due to Basslink, because the power station turns on and off at the same rate as occurs under historical operations.

Figure 4.6 shows the monthly median flows for the historical record and the Basslink scenario.

Both the historical and Basslink (TEMSIM) operation indicate high median flows for the first half of the year, with Basslink slightly higher during the summer period indicating more full capacity discharge. Figure 4.6 shows very low median flows for August and September. The median flows differ over the May to July period with the Basslink median flows being higher in June and July, indicating more winter operation of the power station compared to historical conditions.

Median flows are the flows that are exceeded more than 50% of the time, or the most “common” flows rather than the average flows. A monthly median flow of zero does not mean the power station was not operating at all during a given month, but rather that it was shutdown more than 50% of the time during that month.

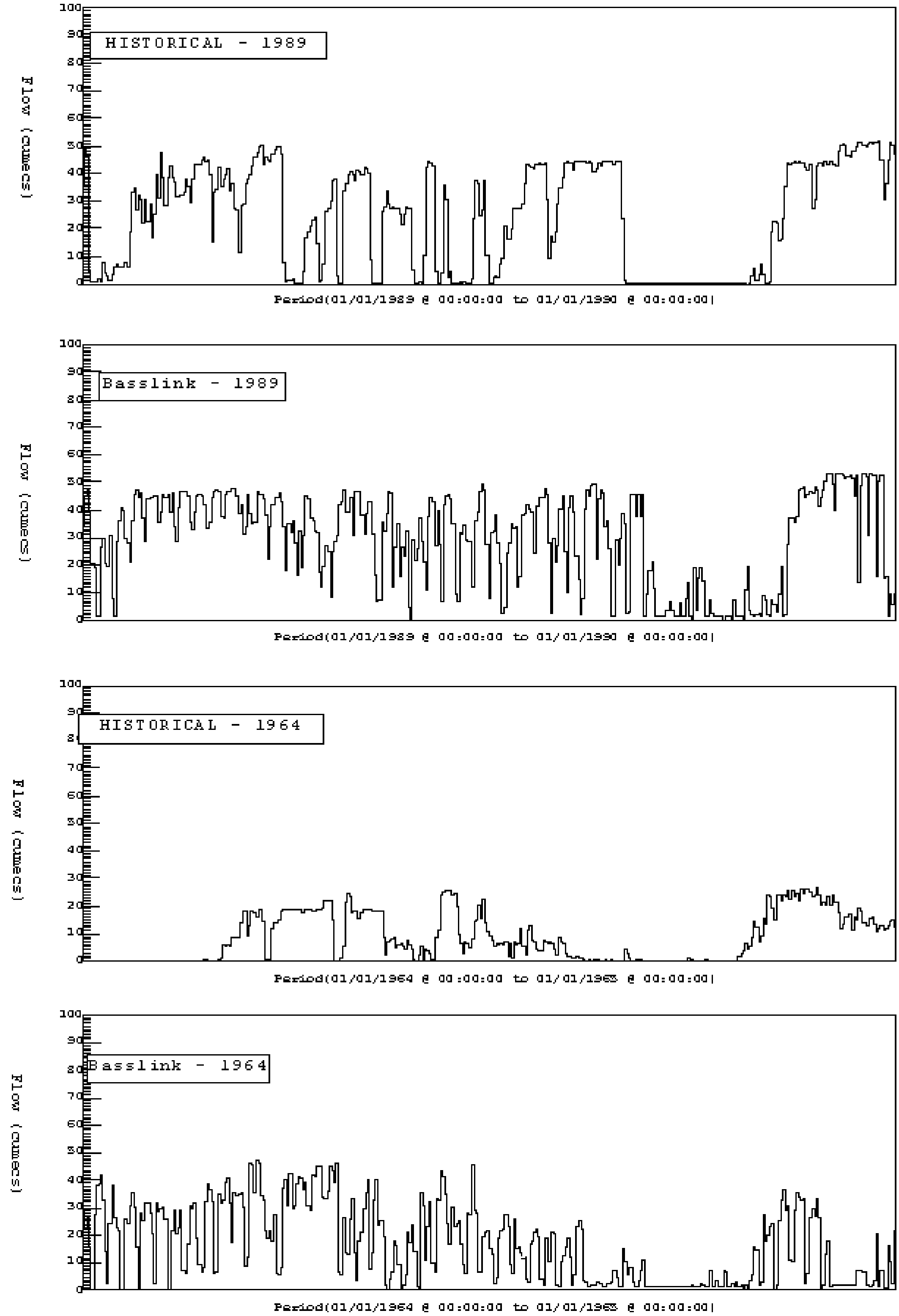


Figure 4.5 Time-series Plots for Poatina Power Station using Daily Data During a Dry Year (1989) and a Wet Year (1964) for Historical Operations and for the Basslink Scenario

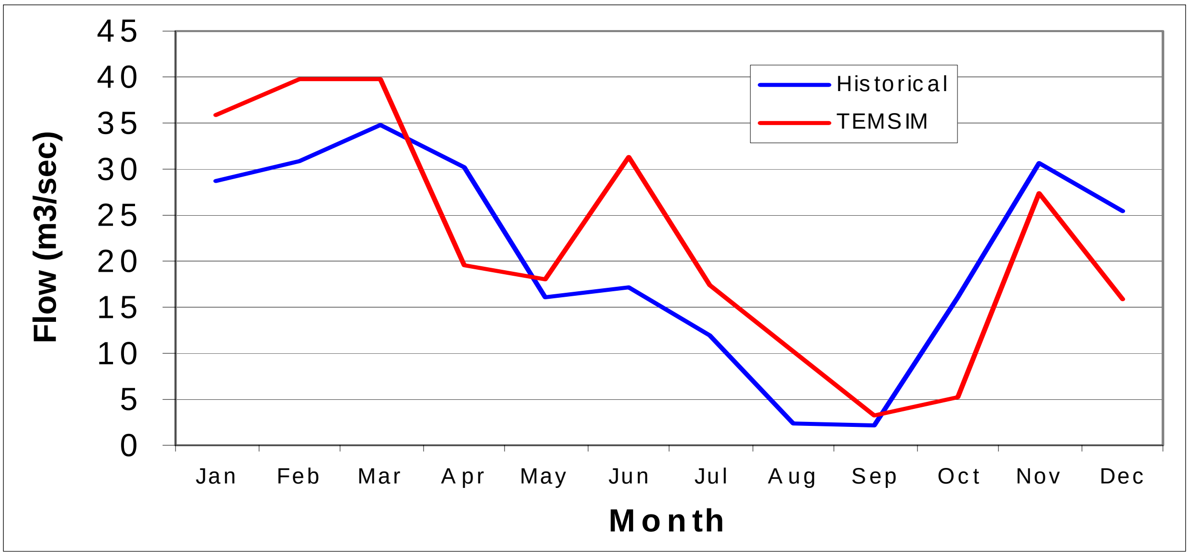


Figure 4.6 Comparison of Historical and Basslink (TEMSIM) Scenario Median Monthly Flows from the Poatina Power Station (1965-1981)

Table 4.1 shows summary statistics comparing actual and simulated hourly flow records at the Poatina Power Station. The period of data examined for this table was 1997-98, because it is the only time period for which hourly data was available. Key points:

- Mean flows are similar, varying slightly depending on the starting storage in Great Lake.
- Minimum flows do not significantly change between present and Basslink.
- The one hour maximum discharge is virtually the same, increasing from 51 to 52 m^3/s under Basslink, and constrained to 52 m^3/s (full capacity discharge) by the capacity of the six generators at the power station.
- The most significant difference is with the number of events. Under historical operations, there are on average each year 74 release events of greater than mean flow, compared to 302 events of greater than mean flow under Basslink. There are on average each year 51 events each year of less than 5 m^3/s discharge; under Basslink there are 269.

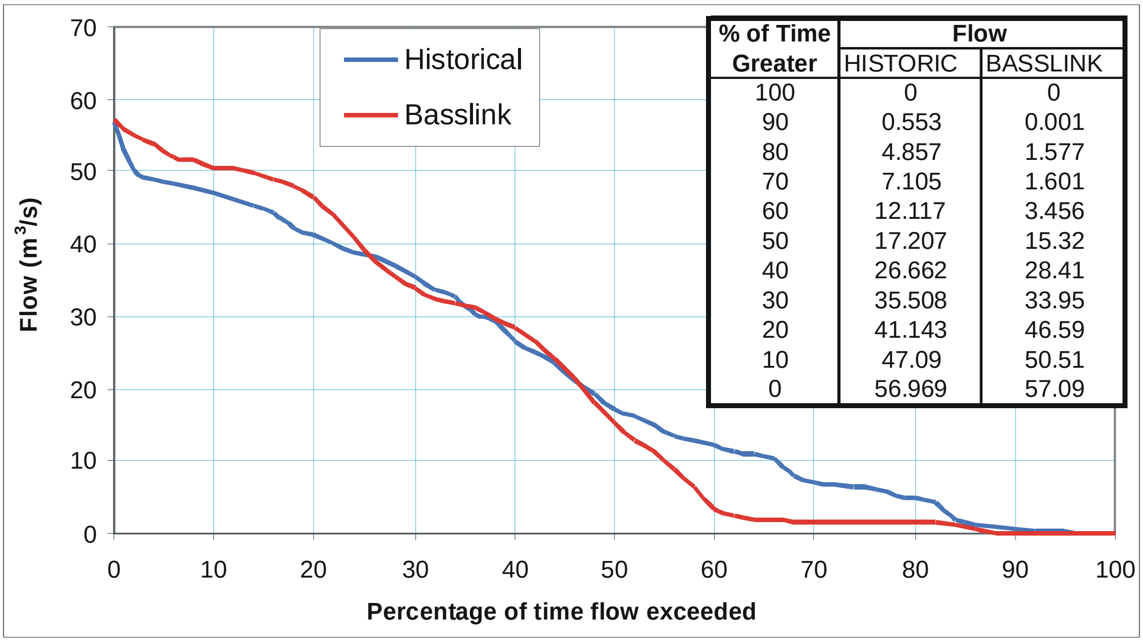
This table examines the number of occurrences of flows at less than 5 m^3/s because the TEMSIM model incorporates a minimum flow during the summer periods of 2.83 m^3/s. Hydro Tasmania is committed to meet all of its existing commitments including provision of sufficient flow at Cressy for the township pumps and irrigation flow requirements, regardless of whether or not Basslink goes ahead.

Table 4.1 Comparison of Actual and Simulated Hourly Flow Records at the Poatina Power Station (1997-1998)

STATISTICS	HISTORICAL OPERATION OF POWER STATION [1]	BASSLINK OPERATION OF POWER STATION
Mean flow (m^3/s)	23.1	21
Annual Mean Minimum Flow 1 Hour Minimum (m^3/s) 7 Day Minimum (m^3/s)	 0 1.7	 0 1.6
Annual Mean Maximum Flow 1 Hour Maximum (m^3/s) 7 Day Maximum (m^3/s)	 51 49	 52 42
The Number of Annual Events Greater than Mean Flow	74	302
The Number of Annual Occurrences of Flows Less than 5 m^3/s	51	269

[1] Record contains missing values.

Figure 4.7 plots the duration curves for historical and Basslink operation, and examines in detail the percent exceedances of particular discharge levels, using hourly data. This figure shows that full capacity discharges (>45 cumecs) are exceeded more often under Basslink than historical operations. The short period of hourly data may be misleading, as maintenance shutdowns may be affecting the historical record whereas maintenance is not built into the TEMSIM model. Additionally, the TEMSIM model bias towards full power station operation over individual or several generators operating (see Section 2.3.2) is likely to be causing an over-estimate of full-capacity discharges from the Poatina Power Station.



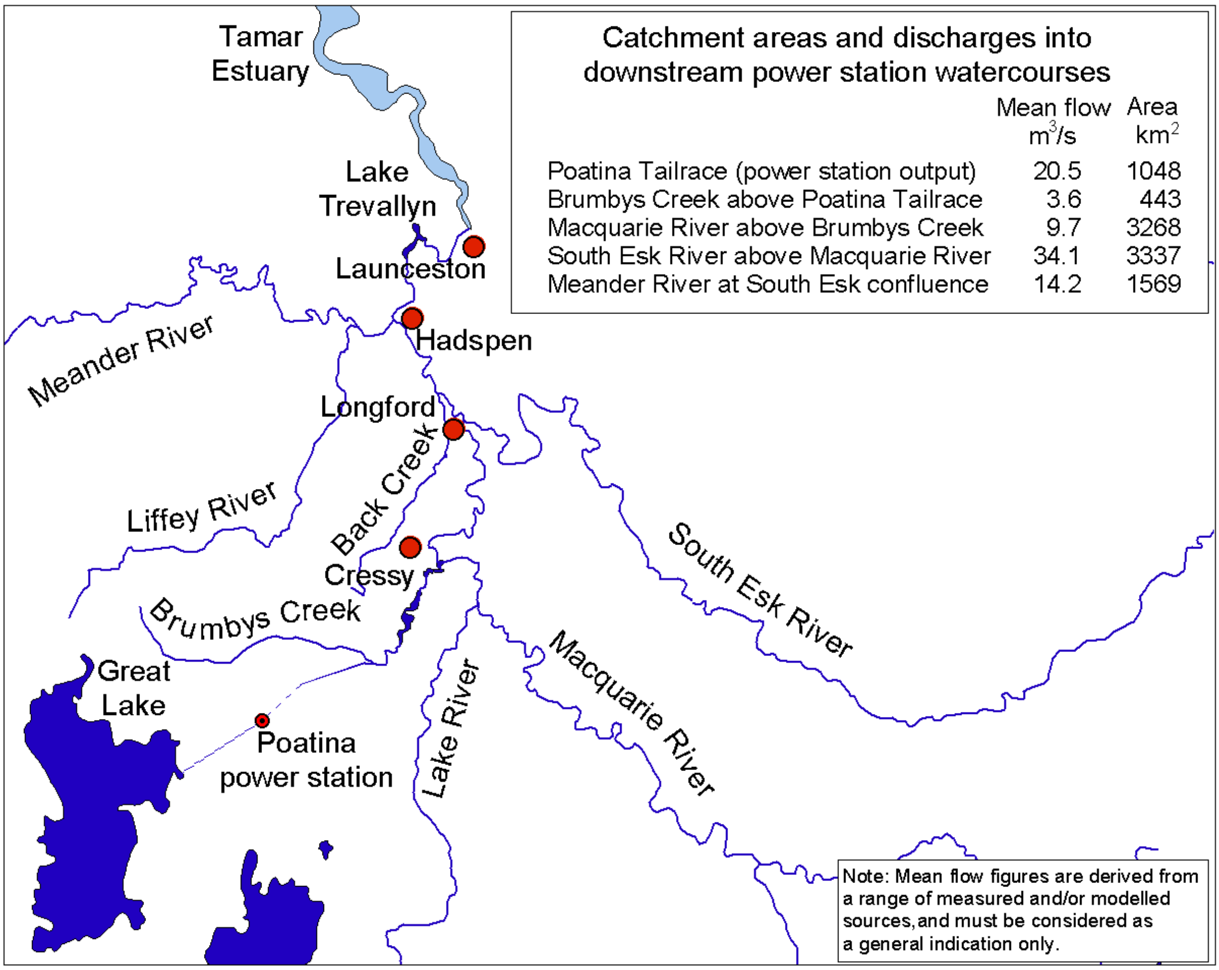
% of Time Greater	Flow HISTORIC	Flow BASSLINK
100	0	0
90	0.553	0.001
80	4.857	1.577
70	7.105	1.601
60	12.117	3.456
50	17.207	15.32
40	26.662	28.41
30	35.508	33.95
20	41.143	46.59
10	47.09	50.51
0	56.969	57.09

Figure 4.7 Flow Duration Curves from Poatina Power Station under Historic and Basslink Operation (hourly data, 1997-98)

4.2.1.3 Downstream Propagation of Flows

Map 4.2 shows the waterways downstream of the Poatina Power Station. The power station discharges via a tailrace canal into Brumbys Creek, which in turn discharges into the Macquarie River, which meets the South Esk River at the township of Longford. Map 4.2 also shows the catchment areas and mean discharges of these three waterways.

Map 4.3 shows the locations of hydrological monitoring data in Brumbys Creek, the Macquarie River and South Esk River downstream of the Poatina power station. Green dots show monitoring stations currently available for this study period, and red dots show locations of historical data. Time periods for data available from each station are provided in Table 4.2. Sites 89, 157, 489, 733 and 768 were used for much of the hydrological analysis presented in Appendix 15. Sites 486, 487, 2089, 2090, 2091, 2092 and a second site at 733 (river level probe established at Panshangar associated with a piezometer site for the geomorphology report, see Section 4.3) were established for this study to provide additional hourly data, and provide a detailed examination of downstream flow propagation (see Table 4.3 and Table 4.4 later in this section).

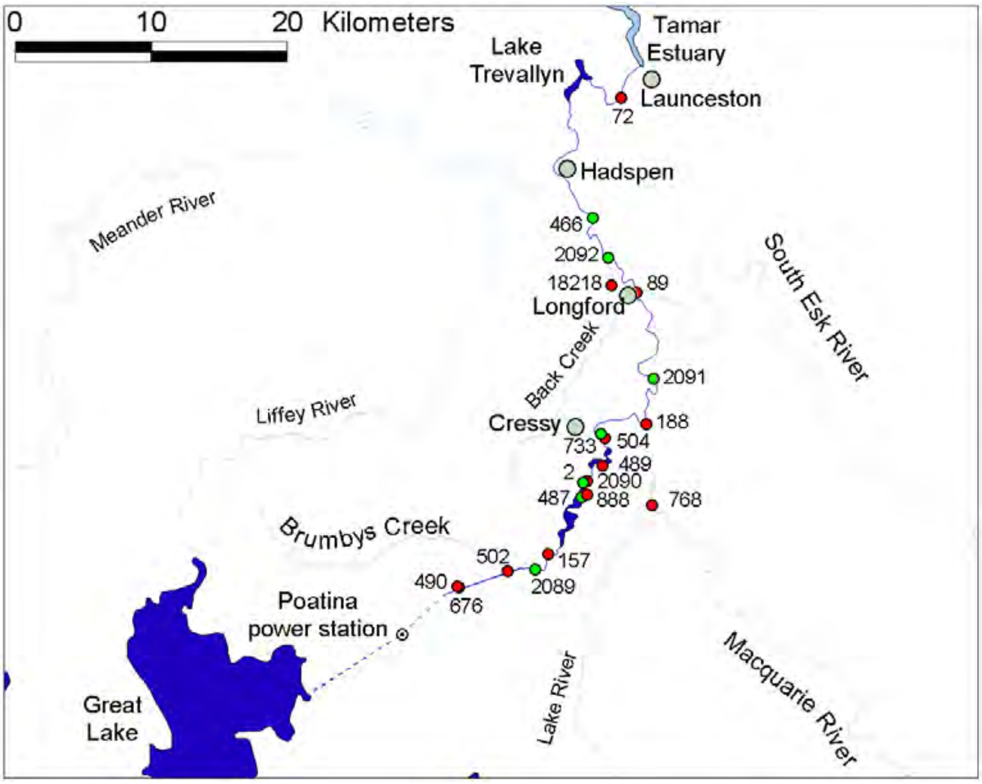


Catchment areas and discharges into downstream power station watercourses

	Mean flow m^3/s	Area km^2
Poatina Tailrace (power station output)	20.5	1048
Brumbys Creek above Poatina Tailrace	3.6	443
Macquarie River above Brumbys Creek	9.7	3268
South Esk River above Macquarie River	34.1	3337
Meander River at South Esk confluence	14.2	1569

Note: Mean flow figures are derived from a range of measured and/or modelled sources, and must be considered as a general indication only.

Map 4.2 Waterways downstream of Poatina Power Station



Map 4.3 Locations of hydrological monitoring sites downstream of the Poatina power station

Table 4.2 Hydrological Sites Downstream Poatina

Site No	*Site*	*Location*	*Start of Record*	*End of Record*
2	BRUMBY CREEK	AT LEES BRIDGE	1996	1997
72	SOUTH ESK	AT LAUNCESTON	1901	1955
89	SOUTH ESK	AT LONGFORD	1957	1995
157	BRUMBY CREEK	B/L PALMERS RIV	1955	1981
188	MACQUARIE RIVER	B/L BRUMBY CK	1957	1990
466	SOUTH ESK RIVER	@ DUMARESQ BR	June 2000	July 2000
487	BRUMBYS CREEK	@ No.1 WEIR	June 2000	July 2000
489	BRUMBYS CREEK	AT No.3 WEIR	1964	1973
490	POATINA T'RACE CANAL	@ No.1 DROP	1964	current
502	POATINA T'RACE CANAL	@ No.15 DROP	1964	1994
504	MACQUARIE RIVER	@ PANSHANGER	1964	1985
676	CRESSY IRRIG CHANNEL	AT INTAKE	1971	1976
733	MACQUARIE RIVER	@ CRESSY PUMPS	1985	current
768	MACQUARIE RIVER	AB WESTMOOR BR	1965	1994
888	CRESSY	RESEARCH FARM	1964	1978
2089	BRUMBYS CREEK	D/S TAILRACE	February 2000	October 2000
2090	BRUMBYS CREEK	D/S No.2 WEIR	February 2000	October 2000
2091	MACQUARIE RIVER	@ OAKSHOT	February 2000	October 2000
2092	SOUTH ESK RIVER	@ JESSIEFIELD	February 2000	July 2000
18218	BACK CREEK	AT LONGFORD	1979	1990

Table 4.3 shows statistics on changes in water levels, lag times, and rates of rise and fall of water levels downstream of the Poatina Power Station for a number of monitoring stations shown in Map 4.3. For this particular event, the power station was off for 48 hours from 5-7 August 2000, and discharging 44.1 m^3/s when on.

Table 4.3 Downstream Water Level Fluctuations in Response to On – 48 Hour Off – On Operation at Poatina Power Station

(note all times are in hours)	***Poatina Power Station Shutdown***		***Poatina Power Station Turn On***		
	*Lag time in start of drop**	*Time taken to drop*	*Lag time in start of rise*	*Time to rise*	*Water level change (m)*
Poatina Tailrace Canal (490)	-	4.0	-	12.5	1.2
Brumbys Creek B/L Tailrace (2089)	0.5	7.5	2.0	11.0	2.3
Brumbys Creek No. 2 Weir (2090)	3.5	13.5	2.5	19.5	1.4
Macquarie River, Panshanger (733.2)	7.0	19.5	9.0	23.0	1.4
Macquarie River at Oakshot (2091)	8.5	17.0	16.0	17.5	1.2
South Esk at Dumaresq (466)	17.5	19.0	19.0	26.0	0.9

*compared to the tailrace canal (490)

Under Basslink, power station shutdown and discharge events are anticipated to be most commonly from 6 to 16 hours. Table 4.4 shows similar statistics to Table 4.3 for a six-hour power station off event on 8 June 2000.

Table 4.4 Downstream Water Level Fluctuations in Response to On – 6 Hour Off – On Operation at Poatina Power Station

(note all times are in hours)	***Poatina Power Station Shutdown***		***Poatina Power Station Turn On***		
	*Lag time in start of drop**	*Time taken to drop*	*Lag time in start of rise*	*Time to rise*	*Water level change (m)*
Poatina Tailrace Canal (490)	-	1.5	-	1.0	1.3
Brumbys Creek B/L Tailrace (2089)	0.5	5.0	1.0	2.0	2.7
Brumbys Creek No. 1 Weir (487)	3.0	12.0	4.0	5.0	0. 6
Brumbys Creek No. 2 Weir (2090)	4.0	10.5	5.5	4.0	1.6
Macquarie River, Panshanger (733.2)	7.0	14.0	9.0	4.0	1.5
Macquarie River at Oakshot (2091)	8.5	13.5	12.0	3.5	1.2
South Esk at Jessiefield (2092)	14.5	11.0	15.5	6.5	0.6
South Esk at Dumaresq (466)	15.5	15.0	16.0	6.5	0.7

*compared to the tailrace canal (490)

It can be seen from these two tables that water levels in Brumbys Creek fluctuated by up to 2.7 m due to power station operations, whereas the measured range was a maximum of 1.5 m in the Macquarie

River, and 0.9 m in the South Esk River. There is some dampening of flow fluctuations with shorter off periods such as predicted under Basslink, but it is not significant.

4.2.1.4 Summary of Basslink Hydrological Changes

In summary, results of the Basslink modelling for the Poatina Power Station show an increase in the occurrence of full capacity discharge (likely to be over-estimated), an increase in the number of on-off events in a given year, and a seasonal shift in power station discharges. Note that there is no increase in the maximum release capacity of the power station, as this is limited by the generator capacity. Rates of river level rise and fall at the power station will not change due to Basslink, although attenuation downstream may change with increased on-off operation.

The most significant change is an increase in the on-off operation of the power station. The number of ‘on events’, indicated by discharge events greater than the mean flow, increase from 74 on average each year with historical operations to 302 under Basslink. The number of ‘minimum flow events’, indicated by discharges of less than 5 m^3/s, increase from 51 on average each year with historical operations to 269 under Basslink. This pattern of on-off operation is consistent throughout the year. The Basslink time series presented in Figure 4.5 do not show 269 off events because they use daily data rather than hourly data.

Downstream of the power station, fluctuations in flow have been measured to be as much as 2.7 m in Brumbys Creek, 1.5 m in the Macquarie River, and 0.9 m in the South Esk River. These flow ranges are not seen to be significantly dampened with Basslink operation of the power station.

4.2.2 Flooding

4.2.2.1 Background

The Basslink hydrology assessment for downstream of Poatina Power Station (Appendix 15) included an assessment of the occurrence of floods.

Floods of large magnitudes are an issue for landowners downstream of the Poatina Power Station. Table 4.5 shows the approximate magnitude and frequency of floods experienced in Brumbys Creek downstream of the Poatina Power Station, in the Macquarie River downstream of Brumbys Creek, and in the South Esk River downstream of the Macquarie River. The flood magnitudes and frequencies shown in Table 4.5 are for historical power station operations, so include discharges from the power station.

Table 4.5 Approximate Magnitudes of Floods downstream of Poatina Power Station

Location	Magnitude of 1:2 Yr. Flood (m^3/s)	Magnitude of 1:5 Yr. Flood (m^3/s)	Magnitude of 1:10 Yr. Flood (m^3/s)	Magnitude of 1:100 Yr. Flood (m^3/s)
Brumbys Creek d/s Palmers Rvt	70	100	125	225
Macquarie River @ Cressy Pumps	150	300	400	800
South Esk River @ Longford	600	1100	1500	4000

From Table 4.5, it is apparent that floods in excess of 1000 cumecs are regularly experienced in the South Esk River.

4.2.2.2 Poatina Power Station 'Flood Rules'

Poatina Power Station operates to a set of "flood rules" that restrict power station operation in times of flood. Present flood rules for the Poatina Power Station limit power station discharges when flow in Brumbys Creek (measured below Palmers Rivulet, Site 157 shown on Map 4.3) to 113.3 cumecs. Additionally, Poatina power station discharge is restricted based on water levels at the Macquarie at Cressy Pumps (Site 733 shown on Map 4.3) as follows:

Station 733 level	Station 733 flow	Poatina Discharge	No. of Generators
Below 2.35 m	<65 m^3/s	No restriction	
2.35 – 2.51 m	65-75 m^3/s	Max. of 22.6 m^3/s	4 generators Efficient Load
2.51 – 2.87 m	75-95 m^3/s	Max. of 17.0 m^3/s	3 generators Efficient Load
Above 2.87 m	>95 m^3/s	Max. of 14.1 m^3/s	2 generators Halfway between Efficient Load and Full Gate

The column titled 'No. of Generators' is an estimate of what the flows relate to in terms of power station operation.

Landowners expressed concerns that the present flood rules governing operation of the Poatina Power Station during floods do not take local floods in Palmers Rivulet and Brumbys Creek sufficiently into account, nor consider South Esk floods which significantly affect landowners downstream of Longford.

4.2.2.3 Basslink Effects on Flooding Downstream Poatina

There is a high level of concern that flooding will be exacerbated under Basslink.

Figure 4.8, Figure 4.9 and Figure 4.10 show flood frequency plots for Brumbys Creek, the Macquarie River and the South Esk River. Note that in these three figures, the historical and Basslink data includes power station flows.

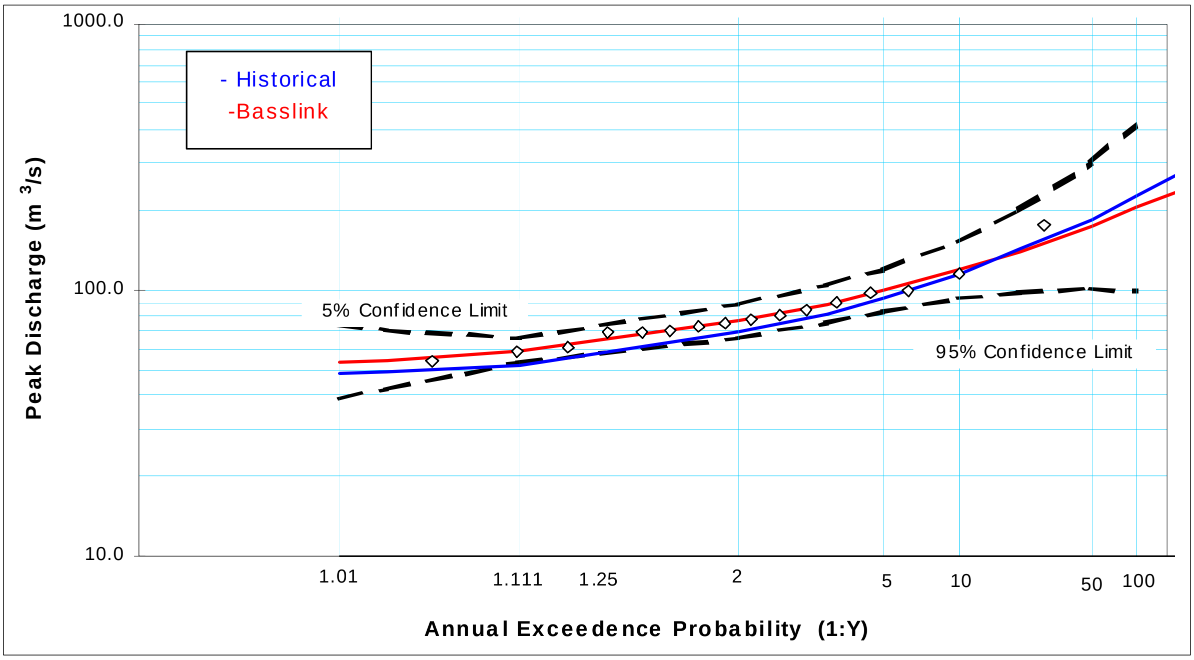


Figure 4.8 Brumbys Creek below Palmers Rivulet Comparison of Flood Frequency Analyses (1965-1981)

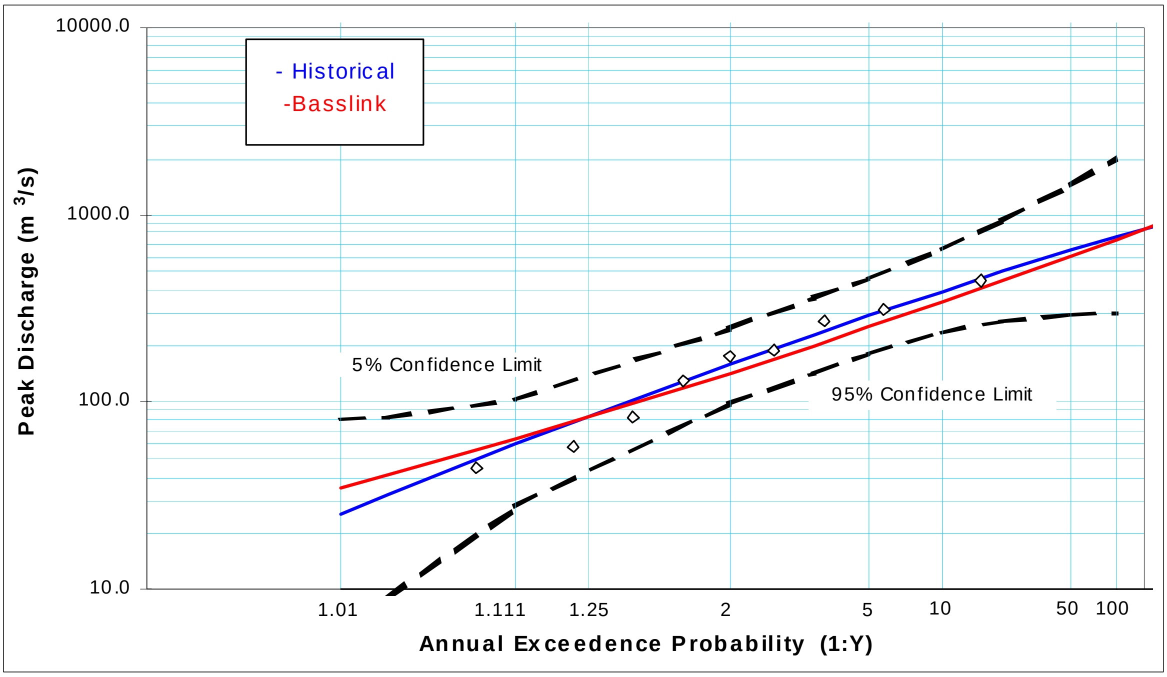


Figure 4.9 Macquarie River at Cressy Pumps Comparison of Flood Frequency Analyses (1986-1994)

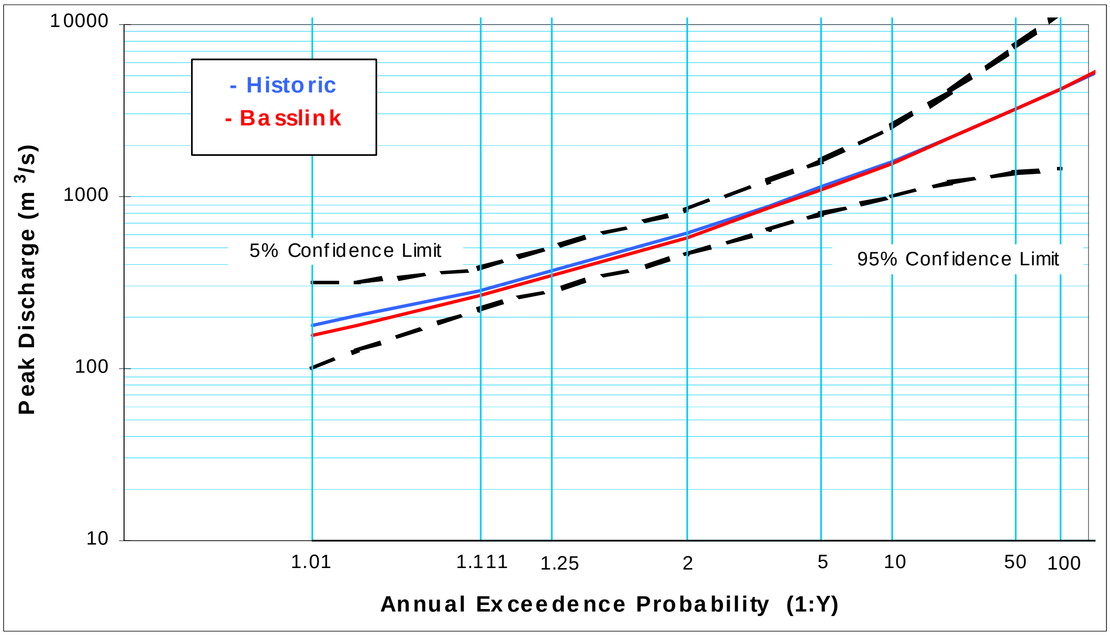


Figure 4.10 South Esk at Longford Comparison of Flood Frequency Analyses (1965-1981)

Flood rules have been in operation historically, and this is reflected in the ‘Historic’ data. However, the TEMSIM model does not include flood rules. Despite the absence of flood rules in the TEMSIM model, the comparisons between Historic operation and Basslink show only very slight changes in Brumbys Creek and the Macquarie River, and no change in the South Esk River. These changes should be negligible with the flood rules in operation under a Basslink regime.

Figure 4.8, Figure 4.9 and Figure 4.10 suggest that Basslink will not change existing flood frequencies in any of the rivers downstream of the Poatina Power Station. Basslink does not change peak flows or annual average flows out of the Poatina Power Station, but most notably affects the timing of power station discharges. Because Basslink hydrological predictions show a slight seasonal shift with increased operation in winter (see Appendix 15 and Section 4.2.1 of this report), the probabilities of Poatina operating concurrent to a natural flood increase under Basslink, and so Hydro Tasmania may have to implement its power station flood rules more often than at present.

4.2.2.4 Adequacy of the Present Flood Rules

The present flood rules date back to the 1960s when the design operating philosophy was to limit Poatina discharge so as not to exceed the maximum natural flow in Brumbys Creek, and similarly limit Poatina's contribution to the flow in the Macquarie River at Cressy to the maximum natural flow from Brumbys Creek. No indication has been found that the rules were updated to reflect changing river conditions such as roadworks, developments near the floodplain, and construction of levees. An assessment of the hydrological record in Brumbys Creek undertaken for these investigations showed that the existing restriction in power station operation when Brumbys Creek flows exceed 113 cumecs may have a limited relation to bankfull flow levels in Brumbys Creek. Thus a rule related to level may be more appropriate.

It was concluded that the present flood rules need to be updated.

Alternative flood rules can be proposed, but further analysis is required to optimise the exact specifications of alternative flood rules, including:

- Hydraulic model assessment of power station impact on a bankfull scenario in Brumbys Creek, Macquarie River and South Esk River.
- Hydrologic modelling to perform an event based assessment of flood rules, the same model should also be used to optimise the proposed rules, especially in relation to timing.
- Hydrologic modelling for long term statistical assessment of the impact of flood rules and Basslink.

4.2.2.5 Conclusion for the Flooding Assessment

In conclusion, floods are recognised as a significant issue for the stakeholders downstream of Poatina. Basslink does not exacerbate the incidence of flooding, but because of the increased winter operation of Poatina there may be an increase in the number of times each year that the flood rules need to be implemented. The present flood rules restricting operation of the Poatina Power Station in times of flood currently under a process of revision, and the analysis of alternative flood rules is in progress. Hydro Tasmania is commited to responsible implementation of flood rules with its operation of the Poatina Power Station, with or without Basslink.

4.2.3 Downstream Poatina Water Quality

4.2.3.1 Methods

Water quality downstream of the Poatina Power Station was assessed by Koehnken, with the full report provided as Appendix 16. This was based primarily on a desk-top study, supplemented by some field data collections and review of data from continuous water quality monitoring stations on Brumbys Creek. Important references for this study included the South Esk Basin State of Rivers Report 1997 (Bobbi *et al.* 1996) and the Hydro Environmental Review for the Great Lake – South Esk Catchment (1999). Appendix 16 provides a systematic assessment of the implications of Basslink on all of the key indicators for Water Quality Objectives provided by the Department of Primary Industries, Water and the Environment (DPIWE).

4.2.3.2 Quality of Influent Waters to Poatina Power Station

Great Lake provides water to the Poatina Power Station, and it in turn receives water from Lake Augusta and Arthurs Lake. These lakes are located in the Central Highlands with largely undisturbed catchment areas. They are characterised by low productivity, neutral pH, and low conductivity and nutrient levels. Turbidity is generally very low, with the occasional exception of Lake Augusta due to wind-blown turbulence.

For approximately 90% of the time under historical conditions, water is withdrawn from Great Lake within 12 m of the lake's surface. Available data show little change in temperature or dissolved oxygen between the lake surface and the intake depth during summer periods. Summer temperature profiles for the lake are very uniform, showing Great Lake to be well mixed, probably due to wind. In other Hydro Tasmania lakes that are known to stratify in summer, low D.O. levels occur at depths greater than 25 or 30 m. Temperature ranges for Great Lake surface water are from 2.4 to 16.4°C.

4.2.3.3 Quality of Water in the South Esk River and Tributaries above Power Station Influence

The Poatina Power Station discharges enter Brumbys Creek, then the lower Macquarie River, and then the lower South Esk River. Background water quality in the upper Macquarie and upper South Esk rivers was characterised by Bobbi *et al.* (1996), and is generally considered good with respect to Protection of Aquatic Ecosystems criteria (ANZECC, 1999). Elevated bacteriological indicators in the rivers necessitate treatment prior to human consumption in the townships which rely on the rivers for water supply.

The upper Macquarie catchment is also primarily used for agriculture and forestry. Water quality is characterised by slightly higher conductivities (142-230 µS/cm), low turbidity (<5 NTU), high levels of faecal coliforms related to stock access to the river, and localised elevations in nutrient concentrations associated with Ross and Campbelltown sewage treatment plants. Dissolved iron and aluminium levels are also elevated, with aluminium values well above the ANZECC (1992) Guidelines values for Protection of Aquatic Ecosystems (the source of which is unknown).

The upper South Esk catchment is very large, and land-use is dominated by agriculture and forestry. Water quality is characterised by low conductivities (<100 µS/cm), low turbidity (<5 NTU), low alkalinity (<10 mg/L $CaCO_3$), and low nitrate and total phosphorous concentrations. Zinc values are slightly elevated, probably related to historic mining activities in the upper catchment area.

These characteristics can be considered "background" water quality conditions for those waters affected by power station operations.

4.2.3.4 Present Water Quality in Brumbys Creek

Water quality in Brumbys Creek presently has the following characteristics:

- Conductivity levels are strongly influenced by power station operations, with higher values similar to background levels (~100 µS/cm) occurring in the winter months when there is an absence of dilution from the power station. With the power station on, summer conductivities are commonly 20 µS/cm.
- Temperatures in Brumbys Creek also vary widely depending on power station discharge patterns. Temperature of water discharged from Poatina reflects temperatures on the Central Highlands, and so tends to be cooler than lowland water temperatures. Summer temperatures are from 2-6ºC cooler at Longford than at Perth. Temperatures quickly increase with the power station off.
- Dissolved oxygen levels passing through the Poatina Power Station are high throughout the year and similar to river conditions. Dissolved oxygen levels show diurnal changes, with lows

coinciding with low night-time temperatures. A decline in D.O. levels in the weir ponds is shown to occur with the power station off within a matter of 3-4 days, because of the absence of water flow, and related to the growth of algae and macrophytes in the ponds.

- Turbidity is low with the power station on (similar to background levels, <5 NTU). High spikes in turbidity (up to 500 NTU) occur and are strongly correlated with storm events, rather than power station activities. These spikes occur with rain events regardless of whether the power station is operating or not, so are presumably created by turbid run-off entering Brumbys Creek. Turbidity spikes also occur during extended power station shut downs due to algal growth in the waterway.
- Dry land salinity salt scald has been observed on the banks of Brumbys Creek, but does not seem to be reflected in the water quality data for the creek.

4.2.3.5 Present Water Quality in the Lower Macquarie River

The dilution effects of the power station are very notable in the lower Macquarie River. Water quality characteristics of the upper Macquarie River are considerably diluted with the inflows from Brumbys Creek. If the power station is discharging, conductivity levels drop from >100 µS/cm to ~20 µS/cm downstream of Brumbys Creek. There is no change in conductivity levels if the power station is not discharging. Total nitrogen and phosphorus concentrations show the same pattern.

4.2.3.6 Water Quality in Back Creek

Back Creek is a tributary of the South Esk River entering approximately 3 km downstream of Longford. Water quality is highly impacted by two sewage treatment plants, one of which treats waste from an abattoir, and agricultural practices. Salinity problems are recognised in this catchment, with conductivities measured at greater than 1000 µS/cm. Poatina Power Station water is diverted into Back Creek during the summer months via the Cressy-Longford Irrigation Scheme, providing considerable dilution to the Back Creek water quality. Conductivities are diluted by an order of magnitude when the irrigation scheme is operating.

4.2.3.7 Present Water Quality in the Lower South Esk River

In the lower South Esk River, conductivity values most closely reflect Poatina Power Station operations, with low values corresponding to the power station being on. Turbidity is generally low, but increases downstream of the Macquarie and Meander river confluences. Elevations in turbidity values occur in response to storm events rather than power station operation. Temperature variations generally follow seasonal trends (low in winter, high in summer). Nutrient transects show decreases downstream of the Macquarie River confluence, and then an increase downstream of the Meander River confluence.

4.2.3.8 Potential Basslink Changes

The primary changes to operation of the Poatina Power Station due to Basslink are an increase in the on-off operation of the power station, an increase in the percentage of time of full capacity discharge, and a shift to more winter operation compared to historical conditions. Consequent changes to water quality are likely to include:

- The on-off operation will result in more variable dilution on a daily basis; instead of long periods of very dilute water or undiluted water, the degree of dilution will vary over the course of a day.
- More uniform operation of the power station throughout the year will increase periods of winter dilution compared to historical conditions, and decrease periods of summer dilution.

- The influence of the power station on water quality downstream of Poatina during the winter months is not likely to be great, because of the greater flows in the upper Macquarie and South Esk rivers.
- During summer months, less continuous operation of the power station increases the number of periods in which the downstream rivers are subject to background water quality conditions.
- An increase in percentage time of full capacity discharge would increase the cumulative duration of very dilute water quality, and reduced summer water temperatures. However, because the full capacity discharge will be delivered in pulses rather than continuously, low temperatures will not be continuous. Compared to the historical power station operating regime where it runs almost continuously during summer months, Basslink will offer more opportunities for downstream water temperatures to rise than under the present regime.
- Shorter duration on-off events will reduce the amount of time that water resides in Brumbys Creek under low flow conditions, and therefore reduce the amount of time warming and oxygen depletion can occur. Most landowner concerns with water quality downstream of Poatina relate to extended periods of power station shutdown, and this would be very unlikely to occur with Basslink.
- Turbidity values are unlikely to change with Basslink, as they reflect storm events more than power station operations.

In general, Basslink will cause greater temporal variability in water quality downstream of Poatina than at present, although the range of water quality conditions present in the downstream catchments will be similar. Fluctuations will be greatest in Brumbys Creek, and diminish with distance downstream. Increased fluctuations in temperature will enable more periods of higher “background” temperatures in summer months; however this benefit will be offset by increased full capacity discharge introducing more of the cooler Great Lake water. Shorter shutdown periods as is tending to occur under existing operating conditions are beneficial in preventing a decline in D.O. levels and temperature elevations in the weir ponds.

4.2.3.9 Management Issues and Mitigation Options

The main water quality management issues under present operations are with regard to summer shutdowns of the power station. The decline in water quality during such events causes problems with irrigation offtakes, difficulties for the Sevrup fish hatchery which is dependent on water extracted from the Weir Pond 3 (Map 4.7), and high temperature and low D.O. impacts on the aquatic ecosystem. These summer shutdowns of more than several days are avoided under Basslink, and more frequent flushing of the weir ponds will maintain better water quality.

Cooler than ambient water temperatures, and fluctuations in downstream water quality conditions, could be addressed by a re-regulation pond or other engineering structure which dampens water level fluctuations. A temporary storage would allow power station water to warm or cool depending on the season, and reduce fluctuations in downstream dissolved oxygen and temperature.

The researcher suggested that consideration could be given to the system of communication with downstream landowners, so that downstream users have warning of changes in water quality. This is probably most pertinent to the Sevrup hatchery, but also to other abstractors of water.

4.2.3.10 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- the monitoring considerations of the individual researchers; and

- ➢ the Basslink-related options arising from those considerations.

4.2.3.10.1 Researchers' Monitoring Considerations

The monitoring suggestions for this study (Appendix 16) included a continuation of the present routine lake monitoring of the Central Highland lakes and the present continuous monitoring of water quality in Brumbys Creek.

4.2.3.10.2 Basslink-related Monitoring Options

The above monitoring activities will be continued both pre- and post-Basslink.

4.3 Environmental Assessment of Land Impacts – Fluvial Geomorphology

4.3.1 Background

The fluvial geomorphology of the waterways downstream of the Poatina Power Station was assessed by Abernethy and Bresnehan, with the full report provided in Appendix 17. Waterways considered in this assessment are Brumbys Creek below the tailrace, the Macquarie River below Brumbys Creek, and the South Esk River below the Macquarie River.

4.3.2 Methods

This study used a number of techniques to assess the present state of the rivers and to predict the changes that might occur with the onset of Basslink flow changes. Methods include:

- Assessment of available background information;
- Field inspections;
- Aerial photo interpretation;
- Process monitoring and data analysis;
- Collection and analysis of sediment samples; and
- Consultation with landowners and others familiar with relevant aspects of the study area.

Field monitoring equipment included near-bank watertable observations wells (piezometers, as used on the Gordon River, Appendix 4) at five sites, channel stage recorders, erosion pins, and surveyed cross-sections.

4.3.3 Present State of the Waterways Downstream of Poatina Power Station

The channels downstream of the Poatina Power Station are highly modified by the high flows discharged from the power station. Channel modifications have also resulted from riparian clearing, weed colonisation, and adjacent landuse practices. In all study reaches, the riparian zone is in a very degraded state, with riparian vegetation largely absent or dominated by weed species. Banks which retain riparian vegetation are more stable than cleared banks, and cleared banks allowing stock access are generally more degraded than those where stock are excluded.

The development of the Great Lake Power Scheme resulted in mean flows in Brumbys Creek increasing from 3.2 m^3/s pre-Poatina to 23.4 m^3/s post-Poatina. Brumbys Creek was also subjected to considerable engineering modifications, including construction of three major weirs in the creek, and channel straightening works. Brumbys Creek had already been subjected to significant riparian clearing and bank straightening works prior to the construction of the Poatina power station, as was shown by the pre-Poatina (1958) aerial photo studies.

The Brumbys Creek channel at present is in poor condition. There is evidence of widespread instability producing both channel deepening and widening. From a comparison of 1998 aerial photos with photos from 1958 (see Map 4.4), Brumbys Creek upstream of Woodside Creek has widened an average of 205% (from 6.1 m to 16.8 m), whereas downstream of Woodside Creek it has widened an average of 338% (5.3 m to 23.6 m).

The extent of bed degradation in Brumbys Creek is indicated by the occurrence of a 'hanging' tributary mouth at the confluence of Woodside Rivulet and Brumbys Creek. The bed of Brumbys Creek is currently some 1.5 m lower than the bed of Woodside Creek. The abandoned former bed of Brumbys Creek also provides evidence for active bed incision. The old bed now forms a shelf or bench in the channel.

Backwaters from the three weir ponds are extensive. They are gradually silting up, due to delivery of eroded sediments from upstream, and are now extensively colonised by willows. During field inspections, several large and small rotational slumps were observed upstream of the Weir 1 pond, ranging in size from less than a metre in width to one that was 8 x 3 metres. These slumps appeared to be less than a day old and most likely occurred due to the recent power station shutdown that enabled the field inspection. Rotational slumping due to rapid draw-down of channel stage is a clear mechanism for bank instability in this reach, and will be exacerbated as banks steepen with continued degradation of the bed.

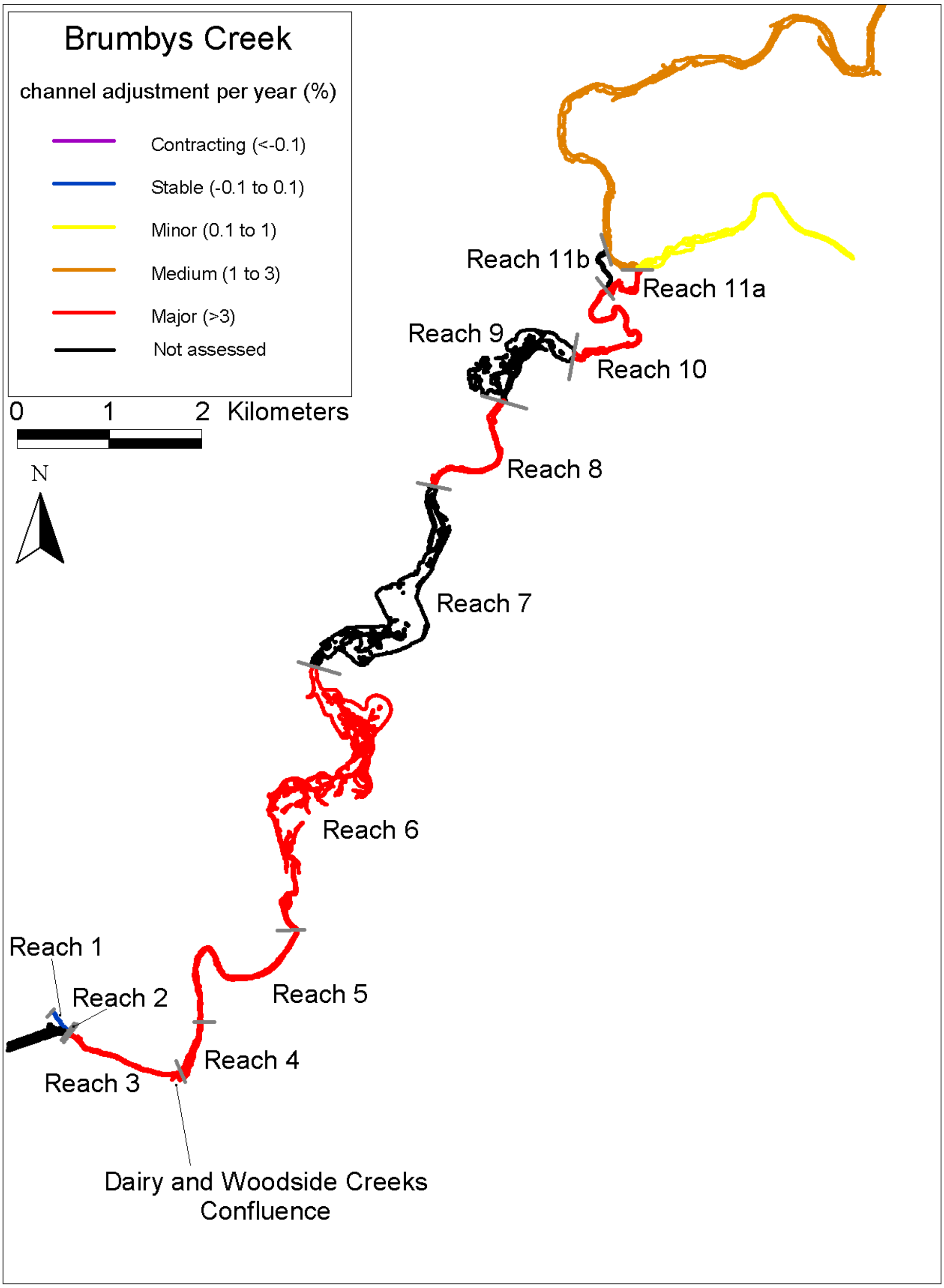
In the lower Macquarie River, the effects of regulated flows are not as immediately apparent. The banks of the Macquarie River below Brumbys Creek appear generally stable, although there are isolated examples of mass failure and cattle damage. Active bank processes include weathering due to subaerial wetting and drying of the upper bank, stock damage where cattle are allowed unrestricted access, and channel modifications due to willows; see Map 4.5. Willow encroachment has divided the channel in a number of places, increasing localised erosion pressures.

In the upstream part of the Macquarie River study reach, banks are characterised by dark brown Canola Clays. Canola Clay is susceptible to the wetting-drying process associated with the water level fluctuations caused by power station operations. Continued wetting/drying has caused small embayments to be eroded into the upper banks. Mass failures are present in the Macquarie River, but the link with powerstation induced draw-down is not as clear as in Brumbys Creek. In the downstream parts of the Macquarie River study reach, erosion on outside bends is occurring, but appears to be most active where willow encroachment has modified the flow. Levees built on the Macquarie River certainly play a role in promoting channel changes during floods, but are unrelated to day-to-day influences of the power station. Comparison of 1958 and 1998 aerial photos show channel widening throughout this reach, increasing as much as 97% on average in reach 4 from 30 to 50 metres wide.

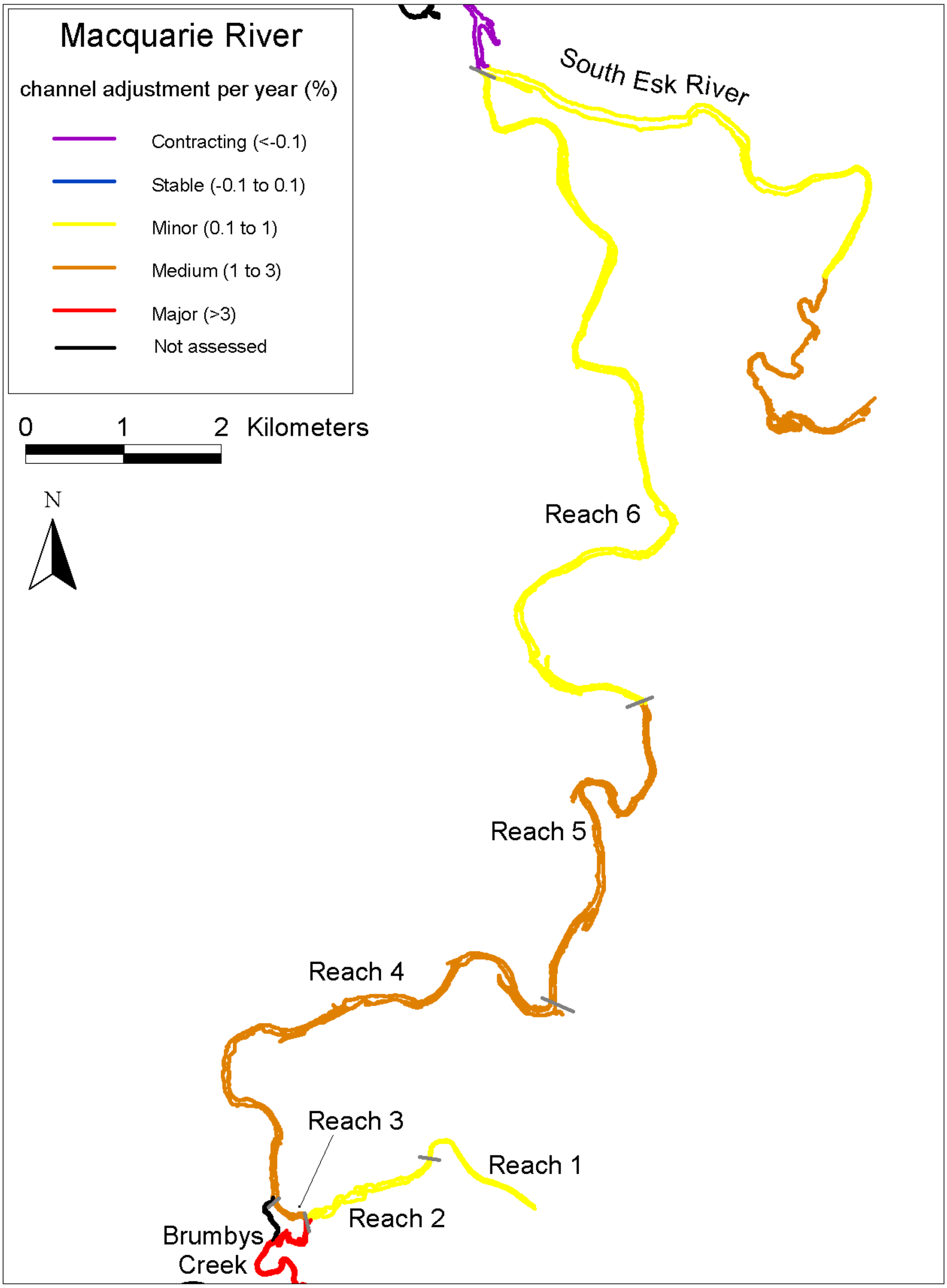
The South Esk River below the Macquarie appears to be stable for the most part, although slumping is apparent on some of the outside banks of meander bends, typically where the riparian zone has been cleared. Willow encroachment also exacerbates lateral channel changes. This river reach is part of a large unregulated catchment with natural variations in flows that tend to dampen the erosive effects of Poatina discharges. Considerable attenuation of Poatina discharge fluctuations has also occurred this far downstream. Generally there has been very little width adjustment of this reach since Poatina began operating, with the widest adjustment being an average of 8% widening in reach 3, from 81 to 87 meters on average (Map 4.6). Some reaches (4, 9) actually show contraction of the channel, the maximum being a decrease of 7% in reach 9, from 75 to 69 m on average.

In summary, the Brumbys Creek channel has widened and deepened significantly since commissioning of Poatina, bank instability is widespread and mass failures common. Some bank erosion occurs along the Macquarie and South Esk rivers as a result of subaerial weathering, stock damage and flow alterations due to willow encroachment. Erosion processes active on the Macquarie

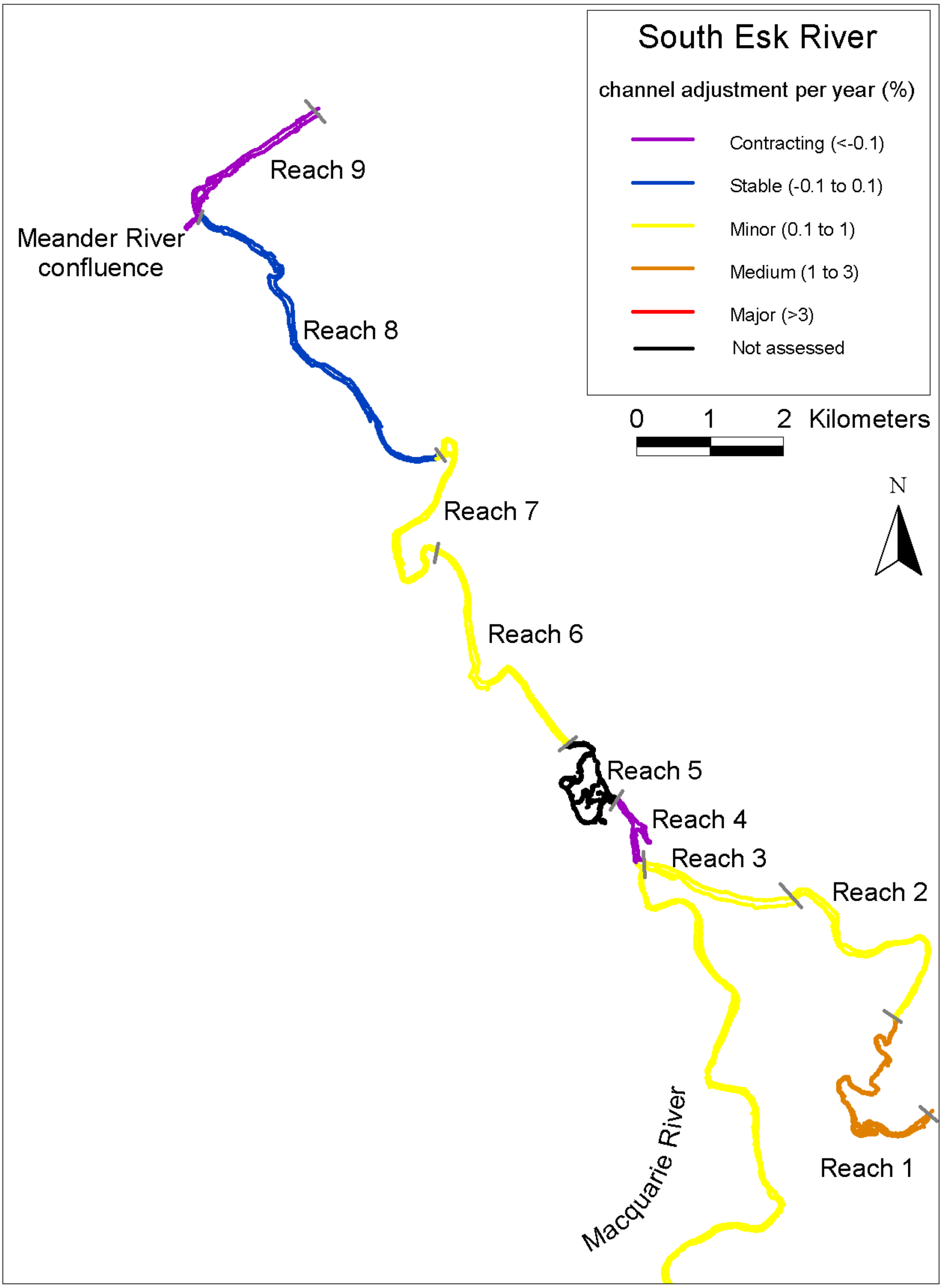
River appear to be exacerbated by Poatina operations, but the same conclusion can not be drawn for the South Esk River.



Map 4.4 Channel adjustment in Brumbys Creek



Map 4.5 Channel adjustment in the Macquarie River



Map 4.6 Channel adjustment in the South Esk River

4.3.4 Potential Basslink Changes

The introduction of Basslink will result in greater flow variability from the Poatina Power Station than under the present operating regime. This will reduce the time available for bank recharge in Brumbys Creek, which in turn will reduce the occurrence of slumping due to bank saturation and rapid draw-down. Increasing the occurrence of full capacity discharges increases the number of high shear stress events imposed on the riverbed and banks, which is likely to accelerate the degradation process. Bed degradation leads to higher and steeper banks, which are then more susceptible to bank failure.

The geomorphological effects of Basslink will not be so apparent in the Macquarie River, and will depend on local bank materials. Erosion processes that dominate the river now will continue to do so. Where bank materials have high transmissivity (e.g. sandy materials), more variability in stage is likely to accelerate erosion. Where bank materials have low transmissivity (e.g. clay-rich materials), banks are likely to be more resistant to scour because the effect of bank recharge/discharge is limited over the shorter periods of stage fluctuation. The main effect of Basslink will be in the upstream parts of the Macquarie River reach, where there will be an increase in the wetting-drying cycles increasing the erodibility of the Canola Clay soils.

Basslink is not anticipated to affect bank erosion in the lower South Esk River, because the influence of Basslink is reduced with distance downstream.

4.3.5 Mitigation Options

Options can be classified into three categories:

1. Water management options, which involve changes in power station operations. Specific options examined were environmental flows, ramp-downs, reduced maximum discharge, and minimising duration of full capacity discharge;
2. Localised treatment options, which address bank erosion and channel degradation where they occur. Specific options examined included bank protection works, bed control works, willow control, river training (re-alignment), broadscale riparian revegetation with natives, and stock management; and
3. Major capital works options, which involve development of infrastructure at the upstream end of the affected waterways to dampen downstream flow fluctuations.

Table 4.6 shows the downstream reaches (shown on Map 4.4, Map 4.5 and Map 4.6) that will be affected by the various mitigation options. Note that Brumbys Creek reach 1, Macquarie River reach 1 and South Esk reaches 1 and 2 are upstream of the effects of Poatina discharges. Brumbys Creek reach 2, Macquarie River reach 2 and South Esk reach 3 are upstream of direct power station inflows, but do receive backwater effects.

Table 4.6 Downstream Poatina Reaches Affected by Mitigation Options for Geomorphology.

Mitigation option	Brumbys Creek											Macquarie River						South Esk River								
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	1	2	3	4	5	6	7	8	9
Rampdowns			✓	✓	✓	✓		✓		✓	✓			✓	✓	✓	✓				✓	✓	✓	✓	✓	✓
Q_{max} magnitude			✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓				✓	✓	✓	✓	✓	✓
Q_{max} duration			✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓				✓	✓	✓	✓	✓	✓
Capital works	✓	✓	✓	✓	✓	✓		✓		✓	✓			✓	✓	✓	✓				✓	✓	✓	✓	✓	✓
Bank protection[1]			✓																							
Bed control		✓	✓	✓																						
Willow control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
River training				✓		✓											✓	✓				✓				
Riparian revegetation	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stock management	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

[1] Incidences of localised erosion that require bank protection treatment can be seen in almost all reaches, however, the banks of Brumbys Creek – Reach 3 require immediate treatment throughout the reach.

Effective mitigation strategies may require a combination of techniques. Controlling water level fluctuations through power station management or a major capital works option will assist in managing the downstream riparian zone, and bank erosion, under Basslink operations.

4.3.6 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- the monitoring considerations of the individual researchers;
- the Basslink-related options arising from those considerations; and
- studies suggested by the researchers which, while not directly measuring Basslink effects, may contribute to better understanding of the fluvial geomorphic processes of the waterways downstream of Poatina Power Station.

4.3.6.1 Researchers' Monitoring Considerations

The authors concluded that this study (Appendix 17) forms a solid baseline against which future channel changes can be measured.

Suggested monitoring activities included pre- and post-Basslink re-surveying of 1998 cross-sections to determine dynamic bed conditions.

A study of sediment transport, in terms of erosion and deposition, was suggested, as were repeated inspections of the condition of the riparian zone, utilising either ground surveys or aerial photography. It was indicated that such work would also be required if riparian vegetation restoration were undertaken.

4.3.6.2 Basslink-related Monitoring Options

Building on the baseline information established by the present study, the Poatina Basslink Monitoring Program (Section 4.9) should include:

- replication of 1998 cross-sections to provide an estimate of bed incision since 1988. This work, performed at pre-Basslink and two and five years post-Basslink intervals, will determine whether the bed is stable, stabilising, or still degrading.
- aerial photography of the riparian vegetation, at 5 and 10 years post-Basslink, to allow for comparison with the aerial photographs taken during the present study.

4.3.6.3 Suggested Studies

A study of sediment transport was suggested by the authors of this study. The method considered for determining erosion was periodic inspection of the main channel bed by trained staff during low flow periods to indicate the condition of the bed sediments. It included relocating painted rocks after Poatina operations as a technique that could be usefully employed to assess movement of the bed material. The method suggested for indicating deposition was repeated cross-sectional surveys in the upper reaches of the Weir 1 backwater.

4.4 Environmental Assessment of Groundwater Impacts

Groundwater impacts relevant to the assessment of environmental issues downstream of the Poatina Power Station are most directly associated with bank erosion issues. When the power station is discharging for prolonged periods, the banks adjacent to the river become saturated, and when the power station next turns off there is considerable pore pressure in the bank sediments draining to the river, leading to draw-down induced bank erosion. Piezometer arrays were installed at five locations downstream of Poatina Power Station for the geomorphology study (Appendix 17), to obtain data on the movement of the near-river groundwater table in response to power station operations.

Dry-land salinity is recognised as an emerging wider management issue downstream of the Poatina power station. Incidences of dry land salinity are also known to occur intermittently along the banks of other rivers adjoining the study area that are not affected by power station flows, indicating salinity is a management issue independent of power station flow regulation. The power station operation increases the near-river ground water table during operation when river levels are high, dissolving and mobilising salts held within the soil. At low-flow conditions, the water in the banks drains back into the channel, leaving the salt to crystallise out on the bank surface. Only one location along Brumbys Creek was observed to show evidence of salt scald. This scald, located immediately downstream of the tailrace, is visible at low flow conditions (see Photo 4.1). The deposits are presumed to be caused by bank infiltration and drainage associated with the operation of the power station, raising near-bank water table levels and mobilising salts. The lack of woody riparian vegetation may also be a contributing factor to the near-bank water table activity producing the salt scalds.

Assuming that a certain degree of bank saturation has to occur before salts are mobilised, Basslink is likely to reduce the occurrence in the vicinity of Brumbys Creek, as the shorter duration power station ‘on’ events should reduce water infiltration into the banks.

Photo 4.1 Salt scald on the banks of Brumbys Creek

4.5 Environmental Assessment of Flora and Fauna Impacts

4.5.1 Scope of this Section

This section reviews environmental information on the flora and fauna downstream of the Poatina Power Station in relation to present status and potential Basslink changes. Specific aspects of the flora and fauna which are examined are the instream biota (Section 4.5.2), and the terrestrial biota (Section 4.5.3).

4.5.2 Instream Biota

4.5.2.1 Methods

Instream biota downstream of the Poatina Power Station was assessed by Davies and Cook and is reported on in full in Appendix 18.

Very little background data were available to the researchers on the instream biota in Brumbys Creek, and so the investigation was based primarily on an intensive field study conducted between July and October 2000. The primary emphasis was on Brumbys Creek, although some assessment was made of the Macquarie River between Brumbys Creek and the South Esk River. Field data was collected on macroinvertebrates, macrophytes and fish. Published data was referred to for platypus, and input from platypus experts was sought. A series of study transects were established to collect data on instream habitat and hydrology, and hydraulic modelling was used to assess changes in habitat availability between present and Basslink conditions.

4.5.2.2 Present Condition – Brumbys Creek

The biology of Brumbys Creek is highly modified compared to its natural state due to channel changes associated with the power scheme, agricultural land clearing, degradation of riparian vegetation, invasion of exotic plants, stock access and irrigation drainage. The three existing weir ponds on Brumbys Creek (Map 4.2) are, in essence, Hydro-created wetlands supporting an entirely different ecosystem than would have existed prior to development of the Poatina power scheme.

Fish fauna in Brumbys Creek is dominated by exotic species, including brown trout, rainbow trout, redfin perch and tench, with an absence of native species other than eels and possibly the native pygmy perch and river blackfish. Eel populations are artificially maintained through stocking in the South Esk catchment. Brown trout and redfin perch have self-sustaining populations, and rainbow trout occur as escapees from the Sevrup salmonid farm in lower Brumbys Creek (near Weir 3). Brumbys Creek supports a significant and self-sustaining trout fishery visited by some 2500 anglers per eyar, and with a national reputation (see Section 4.7.5). Fishery catch-per-unit-effort (CPUE) is variable, suggestive of large variability in recruitment which appears to be dependent on supply of juvenile fish from the Brumbys Creek catchment upstream of the Poatina tailrace.

The macroinvertebrate faunal composition varies greatly between the three major habitat types found in Brumbys Creek, being aquatic macrophyte beds and clay-sands located in the three weir pools, and channel cobble/gravel beds occurring in small pockets elsewhere.

The macroinvertebrate communities in the aquatic macrophyte beds were characterised by high densities of snails, amphipods and microcrustaceans. This habitat area appears to provide the dominant food source for fish and platypus. The success of some native snails (genus *Fluvidona*) and exclusion of exotic snails (notably *Potamopyrgus antipodarum*) were indicative of good water and environmental quality. Some Great Lake species of macroinvertebrates listed under the *Threatened Species Protection Act* 1995 (e.g. *Glacidorbis pawpela*) were found to be present in the macrophyte beds.

The macroinvertebrate population in the channel clay hardpan-sand habitat of Brumbys Creek was dominated by oligochaetes (freshwater worms) and nematodes, with few snails or amphipods. This habitat provides little in the way of food for fish or platypus.

The channel cobble-gravel habitat is only represented in short riffle sections of Brumbys Creek. This habitat is sampled in the RIVPACS (River Invertebrate Prediction and Classification Scheme) bioassessment protocol. Sampling of riffle habitats in Brumbys Creek permitted biological assessment of the Brumbys Creek instream biota utilising the RIVPACS model, developed by Davies *et al.* (1999), and previously described in Section 3.5.3. The overall bioassessment scores (ratios of Observed/Expected taxa, or O/E scores where an O/E of 1.0 means that all of the expected taxa were observed to be present) for downstream of the tailrace in Brumbys Creek were $O/E_{pa} = 0.7$ (B band) and $O/E_{rk} = 0.5$ (B band), whereas in Brumbys Creek upstream of the tailrace $O/E_{pa} = 0.98$ (A band).

The O/E scores show that the macroinvertebrate communities in the channel gravel (or riffle) habitat in Brumbys Creek are significantly modified compared to pre-regulation conditions. The macroinvertebrate community composition now resembles those found in Tasmanian lake/reservoir outflow streams - dominated less by mayfly and stonefly and more by caddis. This is a beneficial alteration from the perspective of trout fishers, as caddisfly hatches are targeted by trout fishers at Brumbys Creek (as they were at the legendary Shannon Rise).

The freshwater mussel (*Velesunio moretonicus*), endemic to the South Esk-Macquarie River system in Tasmania, has established a substantial population in Brumbys Creek associated with the macrophyte beds in the weir pools, but its full extent is unknown.

The aquatic macrophyte communities in the Brumbys Creek weir ponds are extensive in area, diverse and patchy in composition. A clear distinction in macrophyte communities can be discerned between upstream sections and downstream sections of weir pools 1 and 3. The upstream sections showing a highly diverse shallow-water community subject to repeated watering-dewatering cycles in response to power station operations. The downstream sections of weir 1 and most of weir 3 support a more uniform, abundant and less diverse macrophyte community due to the deeper water provided closer to the weirs.

The extensive and shallow macrophyte beds in the Brumbys weir pools are highly suitable frog habitats. Three frog species were detected in this study in high abundance, and there are likely to be more species present. There are also substantial platypus and native water rat populations in Brumbys Creek. Occasional drownings of platypus have been known to occur following a rapid rise in water level, but the population is very abundant and/or highly mobile and in good condition, and drownings are not believed by the researchers to be a significant cause of platypus mortality.

In summary, Brumbys Creek currently supports an abundant and diverse aquatic biota, and a very popular, nationally recognised trout fishery, predominantly sustained by the weir pond macrophyte habitats.

4.5.2.3 Present Condition – Macquarie River

Predominant habitats in the lower Macquarie and South Esk rivers are shallow to deep runs and deep pools.

Channel-edge macrophyte communities appear to be impacted in the Macquarie River downstream of Brumbys Creek (‘Lower Macquarie River’) compared to the Macquarie River upstream of Brumbys Creek, most likely because they have experienced a continuous disturbance regime due to fluctuating power station discharges, but also contributed to by willow infestation. The level of infestation by the Canadian pondweed (*Elodea canadensis*) was less in the Lower Macquarie River than upstream of Brumbys Creek, possibly due to the higher flow rates downstream of Brumbys Creek due to power station discharges.

Main-channel macrophyte communities in the Lower Macquarie River were found to be very extensive compared to the Macquarie River upstream of Brumbys Creek, probably attributable to the frequent occurrence of high discharges from Poatina, resulting in high water clarity.

While the Macquarie River instream fauna were not specifically surveyed in this present study, it is considered that the large abundance of main channel macrophytes has led to a significant increase in abundance of macroinvertebrate taxa associated with these macrophyte species. Fish species are known to include brown trout, redfin perch, tench and native shortfin eel, and possibly the native pygmy perch. The burrowing crayfish (*Engaeus nulloporius*) is known to occur in the Lower Macquarie River, but no data were available. Populations of the locally endemic freshwater mussel were observed to be abundant in the extensive silt-sand patches down-slope from the foot of the extensive macrophyte beds, often associated with dense populations of hydropsychid caddis and sponges on rocks.

The Macquarie River and South Esk River trout fisheries are substantial (discussed further under Section 4.7.5).

4.5.2.4 Predicted Basslink Changes

Substantial areas of the Brumbys Creek weir pools appear to be resilient to fluctuations in water level, with the exception of the upper sections of weir pools 1 and 3 which are highly vulnerable. The plant communities in these sections have partially adapted to the present flow regime, but the degree of likely adjustment to a Basslink regime is not clear. Prolonged day-time exposure of aquatic plants in these sections to high temperatures during dewatering could cause significant impacts. More rapid fluctuations may affect the productivity of marginal and upper pool section macrophyte beds, which may then affect trout fishery productivity and sustainability. More sustained inundation at high flows was considered likely to be detrimental to shore/bank associated sedge/rush communities (e.g, *Carex*, *Juncus*) which are important for weir-pool bank stability and as habitats for adult invertebrates, birds and frogs.

Basslink is likely to lead to minor impacts on channel-habitat macroinvertebrates in Brumbys Creek, including a slight decline in the abundance of filter feeding caddis. Bank-associated biota (macroinvertebrates, fish, macrophytes) are likely to be further impacted by more frequent dewatering events compared to present effects, but the degree of this incremental change could not be quantified.

No significant gains or losses are anticipated for the instream biota in the lower Macquarie and South Esk rivers under Basslink.

4.5.2.5 Mitigation Options and Management Recommendations

Mitigation of Basslink impacts from an instream biological perspective would best be focussed on maintaining the integrity of the macrophyte beds throughout the river channels, and in particular in the Brumbys Creek weir pools. This would best be achieved by maintaining a minimum flow and reducing the rate and magnitude of level fluctuations.

A minimum flow of between 2 and 5 cumecs is recommended to maintain areas of macrophyte habitat. This would allow maintenance of some higher water velocity zones in the weir pools and significantly reduce the dewatering under Basslink. It may also assist in maintaining a proportion of channel edge habitat, as well as lessen risks of platypus drowning by maintaining more stable low-flow levels.

Limiting the duration and magnitude of maximum flows under Basslink would be highly desirable, ideally similar to existing conditions (see Figure 4.7).

Rates of water level rise and fall are currently high to very high, and the researchers recommend that the slowest possible ramping rates should be applied to discharges from the power station.

Dampening of flow fluctuations and reducing the range of flows through a minimum environmental flow and reduced maximum flows could be achieved either by radically altering the intended usage patterns of the power station, or via a major capital works option such as a re-regulation weir.

Construction of a re-regulation pond upstream of Brumbys Creek weir 1 pond is strongly recommended, provided it is of sufficient storage and release capacity to regulate a substantial portion of the Poatina discharges on a daily basis, and it is dedicated to meeting the downstream ecosystem needs. Over-regulation, i.e. the complete dampening of flow variability should, however, be avoided due to the risks of weed infestations (e.g. cumbungi) under very stable flows and the possible reduction of existing macrophyte diversity.

It is further recommended that prolonged Poatina Power Station shutdowns (> 24 hours) are avoided in summer so as to minimise exposure of macrophyte beds during high temperatures, as well as water quality issues.

Other management recommendations include active weed surveillance and management at Brumbys Creek, active management of the trout fishery in Brumbys Creek via the development of a fisheries management plan for the waters downstream of Poatina, and maintenance of the geomorphic integrity of the Brumbys Creek weir pools with particular regard to avoiding excessive silt deposition and willow infestation.

4.5.2.6 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- the monitoring considerations of the individual researchers;
- the Basslink-related options arising from those considerations; and
- studies suggested by the researchers which, while not directly measuring Basslink effects, may contribute to better understanding of the instream biota of the waterways downstream of the Poatina Power Station.

4.5.2.6.1 Researchers' Monitoring Considerations

The authors of this study (Appendix 18) emphasised the need for continuous hydrologic and water quality data at sites in Brumbys Creek and the Macquarie River.

The researchers suggested that macrophyte monitoring should be conducted. This would assist in the assessment of changes in macrophyte abundance and species composition associated with changes in Poatina operations due to Basslink and any other catchment activities.

The researchers also suggested a major survey of trout populations and recruitment conditions.

The study indicated that macroinvertebrate community data collected to date have been restricted to one habitat at one monitoring site downstream of Poatina power station in Brumbys Creek, and that there were no data for the Lower Macquarie River and South Esk Rivers. Some limited, additional data were collected for this study. It concluded that there are insufficient data to form the basis for assessing future change.

The researchers proposed assessment of:

- the pattern of macroinvertebrate abundance and diversity across habitat types, locations and seasons; and
- the minimum number of samples from each of these strata which are required to assess future changes, with a given sensitivity (i.e. alpha level and effect size).

In addition, the study proposed that this phase should involve selection of appropriate control sampling locations (and strata) for assessing changes in lower Brumbys Creek and the Lower Macquarie and South Esk Rivers.

The report also proposed research into populations of burrowing crayfish and endemic freshwater mussels, as well as monitoring the changes to aquatic and semi-aquatic weeds and weir pool morphology.

4.5.2.6.2 Basslink-related Monitoring Options

The information needed to assess Basslink–related changes to hydrology and water quality is presently being gathered via the Waterway Health Monitoring Program. These activities will continue for the duration of the Poatina Basslink Monitoring Program

A biological monitoring program will be developed to provide assessment of the pattern of macroinvertebrate abundance and diversity across habitat types, locations and seasons. It will also determine the minimum number of samples from each of these strata which are required to assess future changes, with a given sensitivity. This initial survey will be followed by routine monitoring every 2-3 years using the quantitative sampling design determined above, in order to assess changes in macroinvertebrate abundance and diversity which may result from Basslink-related changes.

The report proposed monitoring changes to aquatic and semi-aquatic weeds and weir pool morphology. This work is included under the fluvial geomorphology component of the Poatina Basslink Monitoring Program (Section 4.9).

4.5.2.6.3 Suggested Studies

The study suggested that macrophyte monitoring should be conducted. This work would aim to assess changes in macrophyte abundance and species composition associated with changes in Poatina operations due to Basslink, while allowing assessment of and and/or controlling for upper catchment influences on nutrient status, turbidity and hydrology. The researchers also suggested a major survey of trout populations and recruitment conditions as well as research into populations of burrowing crayfish and endemic freshwater mussels. There is presently no information to indicate that Basslink-related operations will impact on any of these biota.

4.5.3 Terrestrial Biota

Griggs and Bresnehan assessed terrestrial flora and fauna downstream of the Poatina Power Station, and the full results of this investigation are presented in Appendix 19. This was essentially a desktop study and examination of aerial photos, supplemented with a number of field visits. The study documented the present condition of the riparian vegetation in Brumbys Creek, and the lower Macquarie and South Esk rivers, and details the threatened flora and fauna recorded in the area.

Native vegetation in the area was originally open eucalypt woodlands and grasslands. Present land use surrounding these waterways is predominantly agricultural, and extensive land clearing has taken place throughout the nearly two centuries since settlement. The native terrestrial biota was significantly degraded prior to the Poatina Power Development. There are small pockets of remnant native vegetation adjacent to the waterways downstream of Poatina, but by far the majority of the riparian vegetation consists of exotic weed species. De-vegetated eroding banks are commonly found throughout the three waterways. Weeds include crack willow, gorse, blackberry, ragwort, hawthorn, broom, sweet briar, cumbungi and pasture species. Willows and gorse are extremely common and are very invasive along the riparian zone.

The major threats to riparian flora are associated with bank erosion and collapse, waterlogging effects, and impacts due to stock access. Where landowners have excluded stock, good recovery of riparian vegetation has occurred, although weed infestation within areas of livestock control are still a management issue.

The GTSPOT database was interrogated to identify any threatened species in the study area. No rare or threatened flora species were identified which are likely to be present in the riparian zone. Some species may be affected by localised flooding, but this is unrelated to power station operations.

The predominant species of terrestrial fauna in the study area are domestic livestock – sheep, horses and cattle. Concerns about stock stranding with fluctuating water levels have been raised by landowners (see Section 4.7.5.2 and Appendix 21).

The weir ponds and areas of willow infestation have created extensive wetlands occupied by native waterbirds. These areas, as well as small streams, ponds, farm dams, offcut stream channels and backwaters, would probably also be utilised by a number of native frog species. The green and gold frog is listed as vulnerable under the *Threatened Species Protection Act* 1995, and has been recorded in the study area (GTSPOT database). Frog species are unlikely to be found in the main channel downstream of Poatina, so they should not be influenced by day-to-day fluctuations in water levels, but they may be affected by dewatering of small permanent pools.

Potential Basslink impacts on terrestrial fauna are:

- Increased occurrence of stock stranding with increased water level fluctuations; and
- Possible dewatering of permanent pools reducing the area of frog habitat.

Mitigation options would incorporate any measures that dampen flow fluctuations, either through changes to the Poatina Power Station operating regime or through construction of a regulating structure to dampen fluctuation in flows. Any mitigation measure which is ultimately put in place should ideally take into consideration the need for natural recharge of billabongs and other off-channel pools during flood events.

Monitoring recommendations include maintaining a program of site visits throughout the three waterways, continuing dialog with landowners and other stakeholders, and playing a supporting or technical advice role in revegetation projects.

4.6 Environmental Assessment of Estuarine Impacts

The TEMSIM model predictions showed no changes to operation of Lake Trevallyn nor Trevallyn Power Station due to Basslink. Therefore, there are no estuarine environmental issues related to Basslink in the area of influence downstream of the Poatina Power Station.

4.7 Environmental Assessment of Socio-Economic Impacts

4.7.1 Scope of this Section

This section examines socio-economic issues downstream of the Poatina Power Station in relation to present status and potential Basslink changes. Specific aspects examined are the cultural heritage (Section 4.7.2), visual amenity (Section 4.7.3), public use and public safety (Section 4.7.4), and industries affected and economic impacts (Section 4.7.5).

4.7.2 Cultural Heritage

A cultural heritage survey was undertaken of the waterways downstream of the Poatina Power Station between November 1999 and March 2000 by a consultant team of McConnell, Stanton and Scripps. Their full report is provided as Appendix 20.

The researchers undertook their study in two parts, the first being a desktop review of the history and heritage of the study area, and the second being a field survey. Field investigations were concentrated on areas considered to have high sensitivity for cultural heritage, primarily areas of aeolian deposition, as well as high erosion potential. The survey areas are essentially the four mapped areas of aeolian sediment on the south bank of Brumbys Creek below Palmers Rivulet, as well as some other specific locations identified through background research. The study also involved consultation with stakeholders, in particular the Aboriginal community through the Tasmanian Aboriginal Land Council (TALC).

The desktop review showed that no previous cultural heritage research had been undertaken in Brumbys Creek, and no cultural heritage values had been recorded.

The cultural heritage study assessed Aboriginal and European cultural heritage values. There is a relatively high potential for Aboriginal cultural heritage to occur in the riverine areas of the Midlands, in particular in riparian areas and in association with the aeolian deposits of the region. Potential European cultural heritage in the region could relate to European land settlement from the 1810s, and associations with settlers from Norfolk Island.

No Aboriginal sites or other Aboriginal heritage values were identified in this study for the Brumbys Creek area. There is good ground surface visibility along the creek so the lack of sites appears to be a real and not apparent result. The absence of Aboriginal sites along Brumbys Creek is likely to be due to much of the area being a swamp prior to clearing. The lack of Aboriginal landscape values in the study area results from the extensive landscape modification carried out by the European settlers since the 1820s.

No significant historic cultural heritage was identified in the study area. A small number of twentieth century historic features of local importance were identified in the general study area. These include a cutting which is part of a 1913 track and ford, a line of mature cypress (c.1913), bridge abutments (c.1913), a farm-house on ‘Formosa’, outbuildings and trees (mid-late 1800s), the ‘Syde’ residence and outbuildings (c.1913), Cressy Research Station (1937-1963 construction), and the three weirs on Brumbys Creek (1960s). These features are mostly well away from Brumbys Creek, and only five of them are on or adjacent to the creek (the three weirs, the sandy cutting and ford, and the bridge remains). There is no expectation that the condition of these features will change markedly under present conditions.

Potential impacts to the identified cultural heritage sites arising from Basslink are limited to bank erosion. Given the understanding of the researchers that such erosion under Basslink would be limited to specific locations in Brumbys Creek, the potential changes due to Basslink are not considered to impact on the cultural heritage values of the area. No Aboriginal sites or values were identified in the areas surveyed, and the potential presence of unidentified sites is considered low. The majority of historical features are located well away from Brumbys Creek, and those in or adjacent to the creek are not in areas of high erosion potential.

The researchers identify no management issues or required mitigation options for downstream of the Poatina Power Station in relation to cultural heritage. They recommend ongoing monitoring of riverbank erosion. If the outcomes of the geomorphology investigations or ongoing monitoring show new areas of high erosion or erosion potential along the waterways downstream of Poatina, these areas should have surveys conducted for cultural heritage values.

4.7.3 Visual Amenity

The Norfolk Plains area, which includes the Cressy-Longford region, is a popular tourist destination, drawing day-trippers and longer term visitors to experience the colonial heritage and pleasant English-style countryside views. In addition to the built history, the Norfolk Plains Group of the National Trust is keen to preserve the hawthorn hedges and riverside willows as an integral part of the scenic values of the area. Tourism-based industries have built up around the heritage attraction of the area, with many historic farmhouses now being operated as colonial accommodation. The tree-lined river views are perceived as an important component of the tourism values of the area. Brumbys Creek is more of an angler’s destination than a sightseer’s, and as such the majority of visitors to locations along the Brumbys Creek have different values and expectations when compared to tourists along the Macquarie and South Esk Rivers.

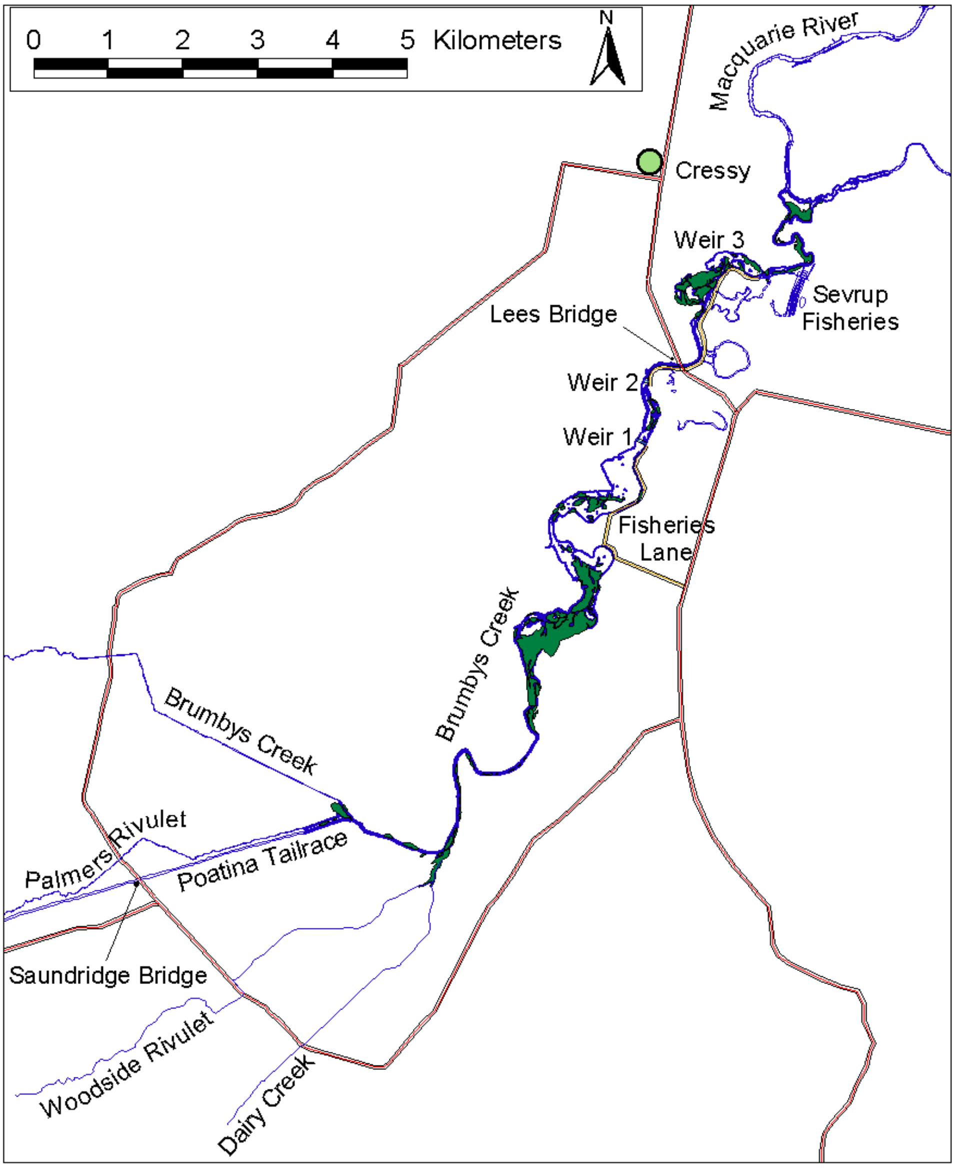
The vast majority of visitors to the area travel by car or bus. Unlike the Gordon River, scenic flights do not form a large part of the visitor experience, and so aerial views of the area are less a concern for assessing visual amenity than land-based views. This notwithstanding, aerial views and vistas as seen from vantage points show waterways more easily discerned by the green stripes of bankside willow infestation than the waters themselves.

The Poatina tailrace and Brumbys Creek can be readily viewed from several public vantage points, shown on Map 4.7:

- A bridge on Saundridge Road crosses the Poatina tailrace upstream of its confluence with Brumbys Creek shows the view of the tailrace looking upstream from this bridge. Brumbys Creek itself is not visible from the Saundridge Road bridge.

- Fisheries Lane provides access to Weirs 1 and 2, and is commonly accessed by a great number of anglers and picnickers. Members of the public are freely able to walk upstream and downstream along the creek banks.

- Lees Bridge provides views of Brumbys Creek between Weirs 2 and 3, shown by Photo 4.3 looking upstream from this bridge looking downstream from this bridge. Members of the public are able to turn off of the main road at Lees Bridge, and drive along Brumbys Creek for a short distance upstream and downstream to where they are able to see the weir ponds themselves.



Map 4.7 Amenity and visual impact locations along Brumbys Creek

The visual impact of Brumbys Creek is primarily with the degree of degradation of the riparian zone, where can be seen either a complete absence of any vegetation at all (see Photo 4.3), or banks completely choked with willows (see the left hand side of Photo 4.3).

The degree of visibility of the Brumbys Creek banks themselves depends on the Power Station operations. Photo 4.2, Photo 4.3 and Photo 4.4 are at high flows with the power station discharging. Photo 4.5 shows Brumbys Creek downstream of Weir 2 (a short distance upstream from Lees Bridge) at low flow with the power station off. With the power station off, erosion of the Brumbys Creek banks is visible particularly where no riparian vegetation is present. Water level fluctuations in response to power station operations in the weir ponds which are most visible to the public range from approximately 0.6 m in Weir 1 pond to 1.6 m in Weir 2 pond (see Table 4.3 and Table 4.4 in this report).

Under Basslink operations, Poatina power station is predicted to turn on and off more frequently, as many as two times a day. Table 4.4 in Section 4.2.1 shows the lag times in water level changes with a short on-off pattern of power station operation. It is likely that under a Basslink operation of the power station the riverbanks at Fisheries Lane and in the weir ponds will be visible to members of the public early in the mornings, but should be largely under water during most daylight hours. Additionally, power station shutdowns occurring more commonly on weekends under a Basslink operation is likely to result in more visible riverbanks during these times. More bank slumping may be visible under Basslink operation of the Poatina Power Station (refer to Section 4.3).

Photo 4.2 Poatina Tailrace, looking upstream from the bridge on Saundridge Road.

Photo 4.3 Weir 2, car park and picnic table, looking upstream from Lees Bridge.

Photo 4.4 Weir 3 looking upstream from Lees Bridge, with a car park located to the right beneath the pines. Note warning sign at extreme right of photo.

Photo 4.5 Brumbys Creek downstream of Weir 2 under low flow conditions, a short distance upstream from Lees Bridge.

Table 4.4 shows that Macquarie River water levels fluctuate 1.2 - 1.5 m and South Esk River water levels fluctuate 0.6 – 0.7 m in response to short-duration power station operations. If Poatina Power Station is off more consistently at night under a Basslink operating pattern, taking lag times in Table 4.4 into account, it is likely that the Macquarie and South Esk rivers will be most commonly seen under low flow conditions. Increased erosion in the Canola Clay soils in the Macquarie River reach downstream of Brumbys Creek may be visible under a Basslink operating regime, although no change in erosion risk is predicted for the South Esk River (see Section 4.3). Where present, riverside willows conceal a great amount of the bank edge beneath their foliage and mask any bank exposure changes (Photo 4.6).

Photo 4.6 The Macquarie River as viewed looking downstream from Woolmers Bridge

4.7.4 Public Use and Public Safety

The main public use downstream of the Poatina tailrace is trout fishing. A significant trout fishery exists at Brumbys Creek, which receives approximately 2,500 anglers a year and a mean of 13,500 total angler-days fishing effort each year, based on information presented in Appendix 18, Downstream Poatina Instream Biota. Anglers fish primarily the runs and pools associated with the three weirs. Access points are as was described in the previous section.

The majority of users are anglers, supplemented by some sightseers and picnickers. Public usage would be greatest on weekends and public holidays.

As for most other popular fishing locations, safety is the user's responsibility. The weirs themselves are unfenced, but are well signposted along the approach roads and along parts of the shore to indicate dangers of fast currents and potential water level changes. Signs are also posted to prohibit the close approach of wading anglers and small boats to the weir drop structures. The drop structures themselves are designed with fencing and handrails to limit access to the high-flow areas surrounding the drop structures themselves. Under Basslink, the water levels in the weirs will fluctuate more than under existing operations, but times of high and low water level in the downstream waterways are likely to be more predictable on a daily and weekly basis.

As presented in the previous section, it is likely that under a Basslink operation of Poatina that the water levels in the weir ponds will be low in the mornings and on most weekends, but are likely to be high during most daylight hours. Because of lag times (refer to Table 4.4), members of the public will be exposed to a rise in water level probably in the late morning. The water level rise will commence in the Weir 1 pond four hours after the Poatina Power Station turns on, so at 11 am if Poatina turns on at 7 am. The water level rise would not be rapid, but would be of approximately 1.6 m over a period of five hours, so will be at high flow at 4 pm and most likely remain there for the rest of the available daylight hours. This is not perceived to be a situation where public safety risks are increased in comparison with existing operations.

Along the Macquarie and South Esk Rivers, public uses include fishing, boating, picnicking and a specifically-zoned section of the South Esk immediately above the Macquarie confluence which is available to jet-skis motor boats and water-skiers. Public uses are not believed to be water level dependent, as the level of water level fluctuation due to power station operations is a maximum of 1.6 m in the most upstream reach of the Macquarie River, and 0.9 m in the South Esk River. If Poatina Power Station is off more consistently at night under a Basslink operating pattern, taking lag times in Table 4.4 into account, it is likely that the Macquarie and South Esk rivers will be most commonly under low flow conditions during daylight hours. This is likely to diminish public safety issues related to high current velocities.

4.7.5 Industries Affected and Economic Impacts

4.7.5.1 Description of Industries

The main industries downstream of the Poatina power station are agricultural, aquaculture and recreational:

- The Cressy-Longford Irrigation-Scheme takes water from the Poatina tailrace. Most of the properties further downstream are private farms, and private land in the Macquarie and South Esk rivers is owned right to the centre line of the river.

- The only other commercial industry is an aquaculture industry in Brumbys Creek, Sevrup Fisheries Pty Ltd, which abtracts water from Brumbys Creek Weir 3 for its operations.

- A major recreational trout fishery exists in the waters downstream of Poatina.

An assessment of these three industries is provided in the following sections.

4.7.5.2 Agricultural Industries

Serve-Ag undertook consultation on potential Basslink issues with all riparian landowners downstream of the Poatina Power Station tailrace in Brumbys Creek, the lower Macquarie River and the lower South Esk River. This consultation was undertaken between June and September 2000, and involved visits and phone calls to 39 riparian landowners. The results of this consultation are provided in Appendix 21 and summarised here.

Visits averaged one hour in length, and involved provision of a summary report describing present hydrology and potential Basslink changes.

The investigators concluded from their extensive consultation that most stakeholders perceive existing conditions as a result of the operations of Poatina as more of an issue than potential Basslink issues. Most landowners felt that Basslink would not cause new problems, but merely add to existing problems.

The issues of bank erosion, stock access and bogging, domestic and irrigation pump intakes, fencing infrastructure and flooding were raised by most landowners for the waterways downstream of the Poatina Power Station. Recreational uses and water quality were also raised. A salinity problem in Brumbys Creek was described. All of these issues are issues with existing operations. The main concerns with Basslink changes were with the increased variability in river level, and with the risk of increased power station operation during flood periods.

The issue of bank erosion far outweighed all other issues and was raised by all landowners without exception. It is perceived that bank erosion is directly related to the frequency of fluctuation and dewatering of the banks, and that the problem will be exacerbated by Basslink operation. Damage to the bank and riparian vegetation by stock is seen very much as a secondary contributor to the erosion problem, though most landowners acknowledged that stock exclusion would be desirable in the long-term.

The authors observed and photographed bank erosion at a number of places. They related these occurrences to rapid river drawdown, as well as frequent submersion of riparian vegetation causing loss of stabilising riparian communities. The potentially compounding effects on bank erosion of stock access and levee banks concentrating flood flows were identified. Information collected by the authors has been incorporated into the assessment undertaken on Downstream Poatina Geomorphology (Appendix 17).

Pump effectiveness is limited by suction height, and so extreme fluctuations in river stage are of concern to irrigators. It is difficult to predict if and exactly which pumps may become inoperable under Basslink conditions, as the difference between operation and non-operation may be as little as 300 mm in height. In many cases, pumps may need to be re-positioned lower to accommodate periods of lower flows (zero discharge out of power station), which will make the pumps more susceptible to flooding during normal power station operations. As a consequence, under Basslink some pumps may need to be replaced by submersible pumps.

Stock access and stranding downstream of Poatina is a major problem for some landowners and a minor problem for others. Stock usually access isolated areas during low flow events, and become stranded as water levels rapidly rise. These occurrences could well increase under Basslink because of the increase in on-off operation of the power station. Very muddy conditions on recently dewatered banks can also cause stock to become bogged. Fencing to low water levels would contain the stock, but frequently fluctuating river levels would make fencing maintenance difficult.

There is a high level of concern that flooding will be exacerbated under Basslink. The main concern is that Hydro Tasmania will not reduce power station operation during floods so that it can meet Basslink power contracts or high price opportunities (note that there is a clearly stated commitment in Section 4.2.2.5 that this will not be the case). Major concerns with the present operation of Poatina during times of flood were noted, particularly with the belief that the flood rules do not take local floods in Palmers Rivulet and Brumbys Creek sufficiently into account, nor do they consider South Esk floods which significantly affect landowners downstream of Longford. The issue of flooding downstream of Poatina was assessed as part of the Downstream Poatina Hydrology Assessment (Appendix 15) and is summarised in Section 4.2.2 of this report.

Water quality issues are also under separate assessment, summarised in Section 4.2.3 of this report and reported on in full in Appendix 16. Water quality concerns raised through the consultation undertaken by Serve-Ag included:

- deterioration in water quality when the power station is turned off under present operations, particularly for lengthy periods of time;
- occurrences of weed and algae in the rivers downstream of Poatina under present operations causing nuisance to pumps, etc; and
- concerns about oxygen levels in the water and timing of their variations under a Basslink operation, in relation to the viability of an aquaculture facility on Brumbys Creek.

One landowner on Brumbys Creek had concerns about salinity under Basslink. He had observed a rapid increase in extent and severity of salt scald during the 1999-2000 summer when Poatina Power Station ran at full gate for much of the time. The researchers did not believe this would be exacerbated under Basslink, because the frequent occurrence of low river levels could provide opportunities for drainage of the saline water from the soil profile.

The investigators reported that most landowners considered that Basslink would not cause any new problems, but merely add to existing problems. The main management issue was in relation to the increased variability in river stage likely to occur with Basslink. The primary concerns related to the impacts on present riverbank erosion, fencing infrastructure and pumping positions. Issues of stock access and bogging and flooding were also raised by most landowners.

The investigators make the point that the reliability of water supply for downstream users, particularly irrigators, may outweigh any issues relating to river stage changes. This stems from concerns that farmers’ water rights will be compromised in order to fulfil electricity contracts under Basslink. Hydro Tasmania has clearly stated that it will adhere to all existing water management commitments regardless of whether or not Basslink is commissioned.

Apparent from the consultation undertaken by Serve-Ag was that there was not always agreement on river management objectives or values. For example, some landowners thought that willows were beneficial whereas others felt they were a problem. Opinions varied widely with regard to the merits of the present communications systems set up by the Hydro, which involves sending of daily faxes to individual landowners on planned power station operations for the next day.

Mitigation options identified by the researchers to address the main Basslink concerns were a re-regulation weir, pump upgrades, erosion protection works, and fencing works.

Monitoring recommendations were to conduct detailed photographic monitoring of the river banks on an annual basis, with a focus on nominated pumping points, fence ends and erosion spots, and to install more water level recorders to better understand effects on localised river stage brought on by Basslink.

4.7.5.3 Aquaculture Industry

An aquaculture operation, Sevrup Fisheries Pty Ltd uses diverted flow from Brumbys Creek Weir No.3 via a pipeline and canal. Sevrup was established post-Poatina construction, and depends to a large degree on the operation of the Poatina Power Station for the viability of its business. Facets of the existing flow regime which are advantageous to this business are the discharge of cooler than ambient summer water, and the dilution of ambient water quality ensuring clean very dilute water for the hatchery. Sevrup can extract up to 4 m^3/s during periods of high flow in Brumbys Creek.

Issues for Sevrup related to present and potential Basslink Poatina Power Station operation were canvassed by Serve-Ag during their downstream stakeholder consultation (Appendix 21). A representative of Sevrup also attended a meeting with relevant Hydro Tasmania Basslink investigators in Hobart in October 2000, and Sevrup was also separately contacted by the researcher for the water quality investigations downstream of Poatina (see Section 4.2.3 of this report, and Appendix 16).

Present issues related to power station operations as described by Sevrup to Serve-Ag include:

- Algae is a problem in Brumbys Creek when Poatina Power Station is not operating;
- Hydro Tasmania sends Sevrup (and any other downstream Poatina stakeholders) daily faxes on flow information. Sevrup has indicated that the information in the faxes is too broad and general, an example being “medium 17-34 cumecs flow range”. Sevrup would like more details on timing of variations within the indicated flow range. Screen damage requiring repair can occur due to changing flows.
- Poatina shutdowns in winter are not a problem for Sevrup, as natural river flow is sufficient. However, summer shutdowns are critical, especially if the shutdown is for more than 12 hours. For summer shutdowns greater than 12 hours, Sevrup has to recirculate water within the farm. Pumping costs average $300/day for recirculation, which allows survival of stock for 1-2 days depending on temperature and river flow. The period around the end of November early December is usually the most critical.

Issues relating to the proposed Basslink operation of Poatina as described by Sevrup to Serve-Ag include:

- The effect of increased fluctuations from Basslink on the Sevrup operation depends very much on whether the fluctuations are at regular times, and more specifically at what time of day Poatina will be discharging. Fish particularly need fresh water at night because the oxygen content of water is lower. Poatina on during the day is preferred by Sevrup, as this would give greater flow through the fishery at night (due to downstream delay of peak).
- It is generally perceived by Sevrup that more fluctuations can cause the farm management more stress and higher work loads.
- Continuation and continued improvement on communication and notification procedures under a Basslink operating regime is considered by Sevrup to be critical to minimising the impact of Basslink flow fluctuations.

The hydrological and water quality analyses suggest that Basslink should not worsen existing issues for Sevrup with Poatina power station operation. The present trend towards compressing power station maintenance periods to as short as possible, and more frequent flushing of the weir ponds will maintain better water quality. Fluctuations in water quality with daily on-off operation may be an issue for Sevrup, although occurrence of cool, diluting flows should occur on a more predictable basis (associated with peak electricity demand) than at present. Additionally, Poatina discharges under Basslink are predominantly during daytime hours, which is optimal for Sevrup.

4.7.5.4 Recreational Trout Fishery

This section is taken with only minor re-arrangement and the author’s permission (Dr. Peter Davies, Freshwater Systems) from Appendix 18 of this report series, on the Downstream Poatina Aquatic Biology and Fishery.

A significant trout fishery exists at Brumbys Creek, with some 2,500 anglers a year fishing primarily the runs and pools associated with the three weirs (IFS unpub. survey data, 1985-1999). Brumbys Creek receives more fishing effort and number of anglers than either the South Esk or Macquarie Rivers, placing it as the fourth most popular of the state's river fisheries after the Derwent, Mersey and Tyenna Rivers based on effort (with a mean of 9.5% of the state's anglers). A mean of 13,500 total angler-days fishing effort is expended at Brumbys Creek per year, representing some $0.4 – 0.5 million dollars expenditure a year, with an annual harvest of around 12,000 brown trout and 2,000 rainbow trout (Table 4.7). The total harvest of brown and rainbow trout is highly dependent on angler effort (Figure 4.11). This fishery is largely self-sustaining, with no active management and no fish stocking, and there have been no substantial trends in fishery performance since 1985. The fishery has a national reputation, and has a relatively high proportion of interstate anglers participating in it.

Trout fishery statistics are summarised in Table 4.7. In this table, '*' indicates costs based on $30/angler-day expenditure figure derived from economic analysis conducted in 1988/89, corrected to $40/day to allow for cost increases to 1999. Effort is in total angler-days, and 'N' anglers includes full season, short duration, juvenile and other license types. The Inland Fisheries Service randomly selects 10% of all full season licensed anglers and mails them a questionnaire at the end of each fishing season (approximately 2,500 questionnaires), with a return rate of approximately 40%.

Table 4.7 Inland Fisheries Service annual questionnaire data for the trout fishery in Brumbys Creek, from 1985/86 to 1998/99.

Season	**N respondents fished this water**	**N respondents**	**%**	**Days/ angler**	**Catch per angler day**		**Total harvest**		**Effort**	**N anglers (all types)**	**$ ***
					Brown	**Rainbow**	**Brown**	**Rainbow**			
1985/1986	36	520	6.9	6.9	1.22	0.12	15118	1495	12398	2282	495920
1986/1987	56	716	7.8	6.6	0.65	0.06	11453	1133	17727	2095	709080
1987/1988	90	902	10.0	6.3	0.96	0.09	14189	1403	14850	2986	594000
1988/1989	91	1089	8.4	7.4	1.17	0.10	17330	1452	14867	2574	594680
1989/1990	137	1216	11.3	8.4	1.23	0.12	28955	2864	23569	3617	942760
1990/1991	72	701	10.3	7.5	1.00	0.09	17258	1536	17926	2844	717040
1991/1992	52	658	7.9	5.6	0.80	0.12	8108	1280	10384	1809	415360
1992/1993	77	999	7.7	6.9	0.50	0.10	5619	1175	11388	2141	455520
1993/1994	47	517	9.1	7.2	1.10	0.13	14185	1788	13391	2400	535640
1994/1995	45	482	9.3	6.6	0.50	0.04	6343	573	13171	2565	526840
1995/1996	47	630	7.5	6.9	0.60	0.31	6627	3468	11194	2077	447760
1996/1997	56	769	7.3	6.1	0.60	0.21	5872	2042	9701	2250	388040
1997/1998	77	417	18.5	5.41	0.88		8363		9425	2488	377000
1998/1999	92	1036	8.9	5.04	0.99	0.19	9756	1951	9840	2636	393600
Mean	**70**	**761**	**9.3**	**6.6**	**0.87**	**0.13**	**12084**	**1705**	**13559**	**2483**	**542374**

Fishery catch-per-unit effort (measured as mean trout catch per angler-day) is comparable to other highly valued Tasmanian trout fisheries (Davies and Thompson 1988), though variable, ranging between 0.5 and 1.2 (Figure 4.11). This variability may reflect large variability in recruitment, although other factors could play a role, such as fishing conditions, fish food availability, fishing success in other waters, or closure of other waters such as Lakes Crescent and Sorell. There are very few suitable spawning areas within the weir pools or within the majority of the channel reaches in Brumbys Creek downstream of the tailrace. There is also limited opportunity for fish to move upstream past the weir structures. Recruitment into the fishery is believed to be dependent on the supply of juvenile fish from a permanent trout population in the Brumbys Creek catchment upstream of the Poatina tailrace.

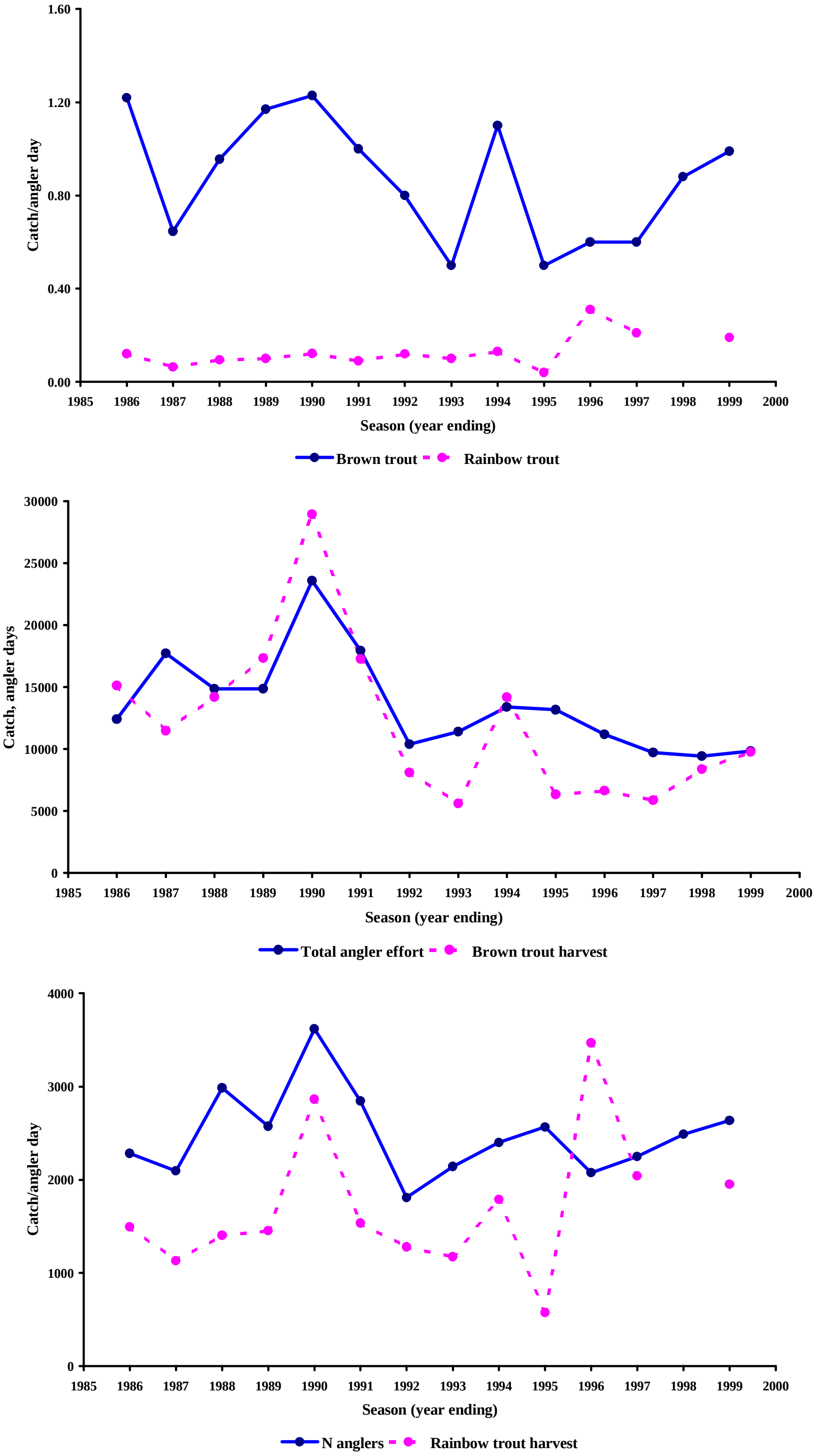


Figure 4.11 Catch per angler day, harvest, number of anglers and total angler effort for the Brumbys Creek rainbow and brown trout fishery between 1985 and 2000. Data derived from IFC questionnaire surveys (see Davies and Thompson 1988).

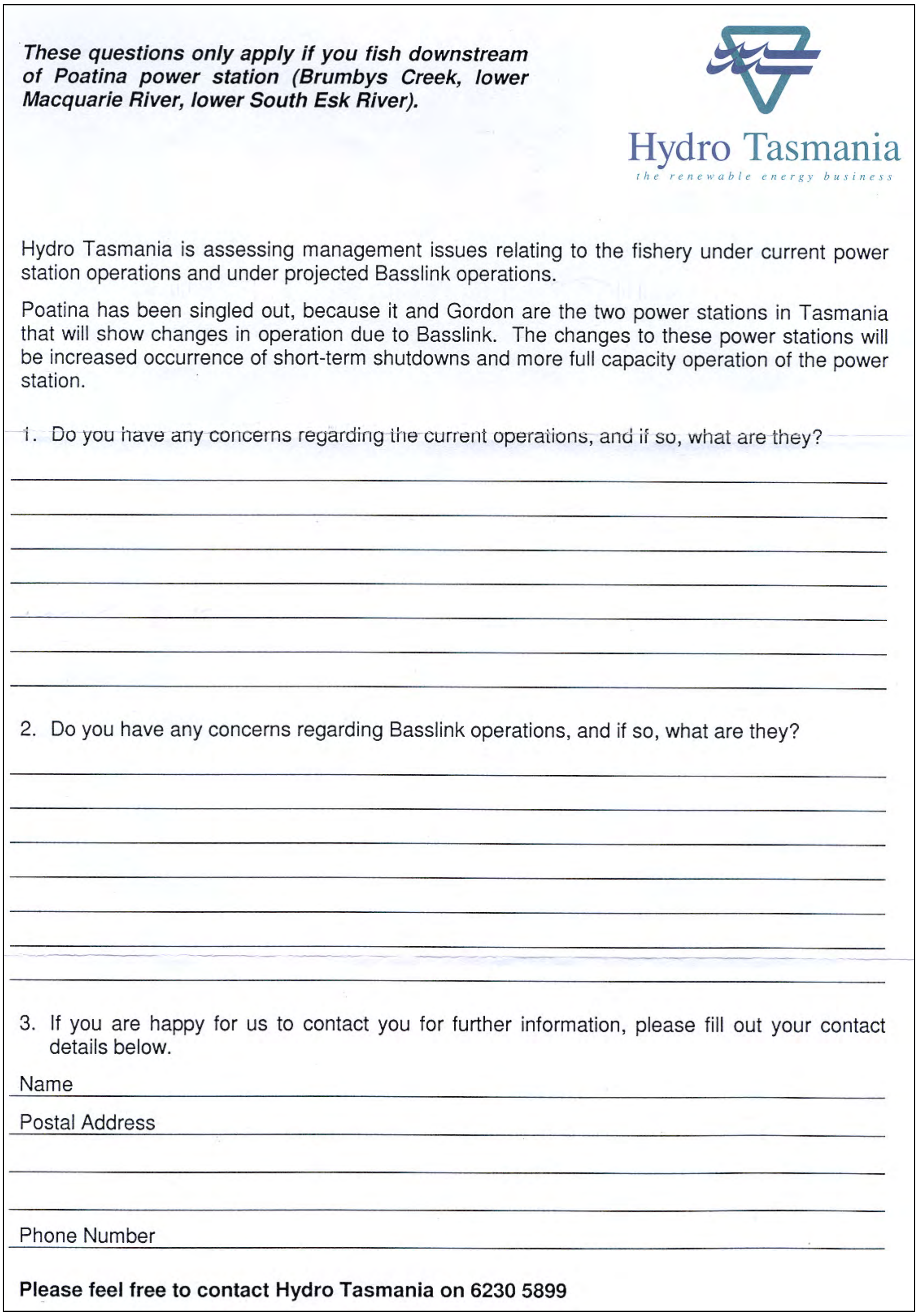
Surveys of sites within the Brumbys Creek catchment in the late 1980's (Davies, IFS unpub. data) indicated a large population of adult and juvenile fish as well as the presence of suitable spawning habitat. It is highly likely that the success of recruitment in that population is dependent on winter-spring rains, as has been found for the St Patricks – North Esk river system by Davies *et al.* (1988). Fisheries management should focus on an adequate supply of recruits to this population.

There are no data on how the fish populations in Brumbys Creek are affected by fluctuating levels associated with existing power station operations.

The Macquarie River and South Esk River trout fisheries are substantial (Davies and Thompson 1988, IFS unpub. data). Approximately 54% of the total fishing effort expended in the Macquarie River is expended in the section downstream of Brumbys Creek (figure derived from IFS questionnaire data). Similarly, a high proportion (42%) of the total fishing effort expended in the South Esk River is expended between the Macquarie River junction and Lake Trevallyn. This amounts to a total of approximately 12,000 angler-days fishing effort (representing an annual expenditure of some $0.5 million) and a harvest of some 11,000 trout, in the two river reaches downstream of Brumbys Creek.

There are four professional trout guiding businesses which rely at least in part on access to and use of the Brumbys Creek-Macquarie/South Esk River system. One of these businesses relies almost exclusively on this system, offering a float-fishing product to clients.

A survey of angler concerns with present and potential Basslink changes to Poatina operation was conducted as part of Hydro Tasmania's Basslink assessment. The survey was very simple, shown in Figure 4.12.



These questions only apply if you fish downstream of Poatina power station (Brumbys Creek, lower Macquarie River, lower South Esk River).

Hydro Tasmania
the renewable energy business

Hydro Tasmania is assessing management issues relating to the fishery under current power station operations and under projected Basslink operations.

Poatina has been singled out, because it and Gordon are the two power stations in Tasmania that will show changes in operation due to Basslink. The changes to these power stations will be increased occurrence of short-term shutdowns and more full capacity operation of the power station.

1. Do you have any concerns regarding the current operations, and if so, what are they?

2. Do you have any concerns regarding Basslink operations, and if so, what are they?

3. If you are happy for us to contact you for further information, please fill out your contact details below.

Name
Postal Address
Phone Number

Please feel free to contact Hydro Tasmania on 6230 5899

Figure 4.12 Angler concerns questionnaire

This survey was included with the Inland Fisheries Service annual questionnaire sent in August 2000 to approximately 10% of all licensed anglers in Tasmania, selected at random from the 21,500 full season, 14 day, 3 day or 1 day Tasmanian licence holders. Of the 2,500 IFS questionnaires sent out, approximately 600 replies were received, so the number of respondents for the 2000 fishing season was ~3% of all Tasmanian anglers. Less than 14% of respondents to the IFS questionnaire fished the areas downstream of Poatina, namely Brumbys Creek, and the lower South Esk and Macquarie Rivers. Hydro Tasmania received 210 responses to the Downstream Poatina angler survey, although 18% of respondents indicated the questions were not applicable to them as they did not fish the areas indicated.

A summary of results of this survey is provided as Table 4.8.

Table 4.8 Summary of results for Hydro Tasmania's downstream Poatina anglers survey

Level of Concern	Question 1	Question 2
Did not feel they could make an informed comment	5.8%	10.5%
None	47.4%	41.5%
Minor	2.9%	5.8%
Some	26.9%	34.5%
Major	1.2%	2.3%
Main Areas of Concern	**Question 1**	**Question 2**
Generally low levels	4.7%	-
Fluctuation of flow/water levels*	11.1%	8.2%
Lowering of levels due to Basslink**	-	15.8%
Great Lake - low or fluctuating levels	6.4%	9.9%
Arthurs Lake - low or fluctuating levels	10.5%	8.8%
Brumbys Creek - low or fluctuating levels	5.8%	3.5%
South Esk - low or fluctuating levels	1.8%	0.6%
Lake Echo - low or fluctuating levels	1.2%	0.6%
Biota***	1.0%	15.8%
Damaged or altered aquatic environment	1.2%	2.9%
Bank erosion	1.2%	0.6%
Limited access surrounding Hydro storages	1.2%	-
Improved management needed	1.2%	2.3%
Monitor levels	0.6%	-
Information needed, e.g. information line on daily operations	2.3%	-
Information needed on intentions and effects of Basslink	-	2.3%
Detrimental to tourism by way of visual pollution	-	2.3%
Response unrelated to fishery	3.5%	12.9%

* Concerns regarding safety issues, stagnation
** Concerns regarding the drawdown of Tas storages to provide power for Vic
*** Concerns regarding the impact on aquatic life and the fishery - insects, foodchain, fish behaviour etc

With regard to present operations at Poatina, 6% of the respondents felt they were unable to make an informed comment, 47% had no concerns, 3% had minor concerns, 27% had some concerns, and only 1% had major concerns. The remaining 16% did not provide an answer for this question.

With regard to Basslink operation of the power station, 11% of the respondents felt they were unable to make an informed comment, 42% had no concerns, 6% had minor concerns, 35% had some concerns, and only 3% had major concerns. The remaining 5% made no comment on this question.

As shown in Table 4.8, the nature of the concerns was broad-ranging and not necessarily restricted to downstream of Poatina.

A significant Basslink concern was with the lowering of Tasmanian storages to provide power to Victoria. Figure 4.1, Figure 4.2 and Figure 4.3, in Section 4.2.1 show that this is unlikely to occur.

Another significant Basslink concern is with the the impact of low or fluctuating Brumbys Creek water levels on aquatic life and the fishery. As stated earlier in this section, there are no data to show how the fish populations in Brumbys Creek are affected by fluctuating lake levels. However, if Basslink operation increases stresses to the Brumbys Creek macrophyte beds as is predicted to occur in Section 4.5.2, this in turn is likely to have significant impacts on weir pool ecosystems, water quality, and fishery productivity.

Concerns regarding public safety issues were addressed in Section 4.7.4, and it is concluded that Basslink does not increase the risks to public safety in comparison to existing operations.

4.7.5.5 Summary of Potential Issues with Basslink for Industries Downstream Poatina

In summary, potential implications of Basslink changes for the three main industries downstream of the Poatina power station have been examined in this section.

Basslink is anticipated by landowners alongside the waterways downstream of the Poatina Power Station to exacerbate existing problems. General concerns exist with bank erosion, water quality issues, salinity concerns, pump set-ups, stock strandings, operation of the power station in times of flood, security of irrigation water supply, and communications from Hydro Tasmania on daily Poatina discharge patterns. Most of these issues are addressed within this report. The most likely Basslink problems affecting their operations are with pump set-ups and stock stranding, and possible bank erosion for a small number of landowners.

Basslink is likely to provide benefits to the Sevrup aquaculture industry, in terms of more predictable power station discharges occurring at times that suit their flow requirements. The business has a perception that more fluctuations will cause increased stress for the business, and improved notifications under Basslink on power station patterns are critical.

The recreational trout fishery in Brumbys Creek may be impacted by Basslink if the projected increased stresses on the weir pond macrophyte beds in turn affect fishery productivity.

4.8 Downstream Poatina Environmental Issues and Mitigation Options

4.8.1 Approach

Similar to the approach taken in Section 3.9 for the Gordon River, for each study undertaken downstream of the Poatina Power Station, the following section (4.8.2) very briefly summarises the researchers' conclusions. This section specifically identifies the changes in the existing condition compared to the pre-dam condition, the present trends in these conditions, and the Basslink trends as compared to present trends.

Section 4.8.3 provides a general overview of the key Basslink environmental management issues. Section 4.8.4 summarises recommended mitigation options. Section 4.8.5 provides a detailed analysis of the major capital works options, and Section 4.8.6 looks in even more detail at the option of a 1.5 Mm^3 capacity re-regulation weir.

Section 4.8.7 summarises the proposed environmental mitigation options for the Basslink development to be implemented downstream of the Poatina Power Station by Hydro Tasmania. The mitigation package includes a substantial commitment to monitoring, which is described in Section 4.9.

4.8.2 Conclusions from the Individual Studies Downstream Poatina

4.8.2.1 Poatina Hydrology

- *Changes Compared to Pre-Dam Condition* – Higher median flows, curtailing of major floods, more restricted flow range, less variability in flows.

- *Present Trends* – Inter-annual variability in power station operations between wet and dry years (more generation in dry years), seasonal variability with more continual discharge in summer and less discharge in winter, and daily variability depending on the daily load requirements and water availability in other storages.
- *Basslink Trends* – Reduced inter-annual variability, more continual discharge throughout the year including more winter discharges, increased occurrence of discharges greater than 40 cumecs, increased fluctuations from off (or a minimum summer flow) to full capacity discharges, more frequent weekend shutdowns of the power station.

4.8.2.2 Downstream Poatina Flooding

- *Changes Compared to Pre-Dam Condition* – Poatina Power Station introduces additional water into the South Esk catchment due to diversion of Great Lake catchment.
- *Present Trends* – Exacerbation of floods downstream of Poatina is curtailed due to flood rules restricting power station operations. These rules require revision and updating, which will require substantial analysis.
- *Basslink Trends* – Changes in frequency or magnitude of floods downstream Poatina due to Basslink do not show in any flood frequency plots for Brumbys Creek, or the lower Macquarie or South Esk rivers. Increased operation of Poatina in winter with Basslink increases the probability of Poatina operating concurrent to a natural flood in the South Esk catchment, so the Poatina flood rules may need to be implemented more frequently.

4.8.2.3 Downstream Poatina Water Quality

- *Changes Compared to Pre-Dam Condition* – Reduced summer temperatures with power station on. When power station off in spring, summer and autumn, get increased temperatures and reduced dissolved oxygen in weir ponds. Power station dilutes water quality parameters downstream when on, and when off these parameters return to background levels. Evidence of dryland salinity on banks of Brumbys Creek.
- *Present Trends* – Long-term changes to catchment water quality are controlled by land-use practices, and dilution by power station discharges. There are seasonal trends in many of the water quality parameters. Salinity in Brumbys Creek probably worsening over time if driven by inundation.
- *Basslink Trends* – Improved flow-through in weir ponds with Poatina off for shorter durations. Downstream rivers experience slightly lower summer temperatures due to increased full capacity discharge. Rapid fluctuations in water quality parameters will be experienced, diminishing with distance downstream. Salinity along Brumbys Creek banks will decrease if driven by inundation, but increase if driven by fluctuations.

4.8.2.4 Downstream Poatina Fluvial Geomorphology

- *Changes Compared to Pre-Dam Condition* – Alterations to river channels from tailrace down to South Esk River. Brumbys Creek channel has widened up to three times its original width, the bed is 1.5 m lower at Woodside-Dairy Creeks, and bed is not armoured. Macquarie River has widened. Multi-channel reaches formed by willow colonisation in all downstream reaches. Weir pond backwaters are silting up from upstream erosion, and being further colonised by willows.
- *Present Trends* – Brumbys Creek will continue to widen and degrade. Macquarie and South Esk rivers will continue to degrade due to power station operations combined with land-use practices,

particularly if willows continue to encroach. Weir pond backwaters will continue to infill with sediments.

- *Basslink Trends* – A change in the nature of the existing channel degradation processes in Brumbys Creek, which will experience a switch in erosion mechanism from seepage-induced draw-down failures to scour of toe and bed leading to slumping. In upper Macquarie (Canola Clay soils), increase in wetting-drying cycles in upper portion of banks will increase definition of a step in this part of the bank; this could be colonised by grasses tolerant of frequent short-term inundation. In sandier soils in the Macquarie and South Esk rivers, potential for increase in scour, undercutting and small-scale failures.

4.8.2.5 Downstream Poatina Riparian Vegetation

- *Changes Compared to Natural* – Most native vegetation has been cleared from the riparian zone in Brumbys, Macquarie and South Esk rivers over the last 180 years since European settlement, and cropping/pasture dominate along with weed species. Domestic stock dominate the fauna adjacent to the waterways, and the native terrestrial species recorded in this region have widespread ranges within the state.
- *Present Trends* – Willows are encroaching in all of these waterways. The small remnants of native riparian vegetation are impacted by erosion and stock access to riverbanks. Some landowners are trialling revegetation plots, and exclusion of cattle to assist natural revegetation.
- *Basslink Trends* – Issues for the riparian vegetation are related to bank erosion. Fluctuations in power station operation may also affect the success of riparian revegetation plots through erosion or excessive inundation.

4.8.2.6 Downstream Poatina Instream Biota

- *Changes Compared to Pre-Dam Condition* – Brumbys Creek below tailrace is highly modified and has a radically different ecosystem in the extensive weir pools compared to natural. Channel biota are significantly impacted for macroinvertebrates compared to natural, and some Central Highlands taxa also present. Brumbys Creek weir ponds support a healthy, productive and successful trout fishery with substantial and diverse macroinvertebrate communities, platypus populations, frog populations, and the endemic freshwater mussel. Lower Macquarie River and South Esk rivers experienced a loss of fringing macrophytes (similar to upper reaches) but still retain viable and significant trout fisheries, and a compensatory and extensive expansion of macrophytes across the channel due to higher water clarity from power station discharges.
- *Present Trends* – Sections of Brumbys Creek weir ponds dewatered over summer, but generally are in quasi-equilibrium and very productive. Upstream degradation of channel will eventually negatively impact on macrophytes and invertebrates by gradual siltation of weir ponds (not sure of timeframe or extent).
- *Basslink Trends* – Increases in flow fluctuations will increase stresses on macrophytes in weir ponds, with likely significant impacts on weir pool ecosystems and fishery productivity, and will increase stresses on macroinvertebrates and fish in main channel. Dewatering periods of only a few hours could impact on trout recruitment by dewatering trout egg nests (redds) where these are located within Brumbys Creek itself (unknown at this stage). Increased occurrence of maximum discharges would also stress the instream biota. There may be impacts for platypus, but these are unlikely to affect the population as a whole.

Because socio-economic issues do not lend themselves to the same approach as the issues for the physical environment, a summary of socio-economic issues in relation to Basslink is left out of this section and included in the following section.

4.8.3 Downstream Poatina Basslink Impacts

This section pulls out from the previous section the aspects of the downstream Poatina river system most subject to fundamental and adverse changes due to Basslink – water quality, geomorphology, instream biota, and socio-economic issues.

These impacts are re-iterated here. Basslink trends are relative to existing conditions:

- *Basslink Trends for Water Quality* - Improved flow-through in weir ponds with Poatina off for shorter durations. Downstream rivers experience slightly lower summer temperatures due to increased full capacity discharge. Rapid fluctuations in water quality parameters will be experienced, diminishing with distance downstream. Salinity along Brumbys Creek banks will decrease if driven by inundation, but increase if driven by fluctuations.
- *Basslink Trends for Fluvial Geomorphology* – A change in the nature of the existing channel degradation processes in Brumbys Creek, which will experience a switch in erosion mechanism from seepage-induced draw-down failures to scour of toe and bed leading to slumping. In upper Macquarie (Canola Clay soils), increase in wetting-drying cycles in upper portion of banks will increase definition of a step in this part of the bank; this could be colonised by grasses tolerant of frequent short-term inundation. In sandier soils in the Macquarie and South Esk rivers, potential for increase in scour, undercutting and small-scale failures.
- *Basslink Trends for Instream Biota* - Increases in flow fluctuations will increase stresses on macrophytes in weir ponds, with likely significant impacts on weir pool ecosystems and fishery productivity, and will increase stresses on macroinvertebrates and fish in main channel. Dewatering periods of only a few hours could impact on trout recruitment by dewatering trout egg nests (redds) where these are located within Brumbys Creek itself (unknown at this stage). Increased occurrence of maximum discharges would also stress the instream biota. There may be impacts for platypus, but these are unlikely to affect the population as a whole.
- *Basslink Socio-Economic Impacts* - Fluctuating water levels under Basslink will cause problems for landowners with pump-set ups, as well as increase the risks of stock strandings. Increased work stresses associated with fluctuating water levels may be an issue for Sevrup Pty. Ltd. Negative impact on the recreational trout fishery in Brumbys Creek may arise due to projected impacts on macroinvertebrate food supplies.

Hydrology is not included because it is a cause of the environmental impacts and not an effect. Flooding is not included because there are no anticipated Basslink issues provided an effective flood operating rule is in place. Riparian vegetation is not included because the Basslink issues are closely intertwined with geomorphology.

4.8.4 Downstream Poatina Basslink Mitigation Options

For the four disciplines which result in significant Basslink impacts, the identified mitigation options are summarised below. Researchers were given no constraints on options for mitigation, so those listed are the full range of ideas provided. Assessment of the different options is pursued in Section 4.8.4.

- *Mitigation Options for Water Quality* - a re-regulation pond or other engineering structure which dampens water level fluctuations. A temporary storage would allow power station water to warm or cool depending on the season, and reduce fluctuations in downstream dissolved oxygen and temperature.
- *Mitigation Options for Fluvial Geomorphology* - localised treatment works for channel degradation such as bank protection and stabilisation works, river training works in certain locations, and revegetation with native species. Major capital works options such as a re-regulation pond to dampen downstream flow fluctuations would be very beneficial. Water

management options include reducing maximum discharge, minimising duration of full-capacity discharges, and power station ramp-downs.

- *Mitigation Options for Instream Biota* - minimum environmental flows and ramp-downs, reducing maximum discharges, trout re-stocking, creation of a trout spawning channel, or dampening (re-regulating) flow fluctuations by some capital works option.
- *Mitigation Options for Socio-Economic Issues* - any measures which dampen water level fluctuations. Additional specific options for landowners are to fund upgrading of pumps, and assist in fencing for stock exclusion, including provisions for off-river watering of stock. Improved communications on daily power station discharge patterns have been widely suggested.

To summarise, fluctuating flows under Basslink will or may cause the following impacts downstream of Poatina Power Station:

- continued channel degradation with changes in the mechanisms, especially in Brumbys Creek;
- stresses on instream biota particularly in Brumbys Creek;
- landowner pump problems;
- potential for increased stock strandings;
- increased work stress for Sevrup; and
- potential impacts on the Brumbys Creek recreational trout fishery.

Additionally, increased shutdown occurrences will or may cause:

- increased exposure of macrophyte beds in Brumbys Creek; and
- increased occurrence of erosion due to wetting-drying.

Therefore, significant aims of any Basslink mitigation options are to reduce downstream flow fluctuations; and avoid exposure of macrophyte beds in weir ponds.

Mitigation measures are required to mitigate the Basslink effects downstream of the Poatina Power Station. Options presented by researchers are summarised in Table 4.9.

Table 4.9 Summary of Mitigation Options for Basslink-related Environmental Management Issues Downstream Poatina

AREA OF STUDY	MITIGATION OPTIONS
WATER QUALITY	More continual power station discharges to dilute catchment derived water quality problems. This could be achieved by a re-regulating weir or other structures which decrease flow variability.
GEOMORPHOLOGY	A range of localised treatment works such as bank protection and stabilisation, river training and revegetation. Dampening of flow fluctuations for downstream Brumbys Creek either with a major capital works option or through modifications to power station operations. Reduce/minimise full gate discharges, imlement ramp-downs.
INSTREAM BIOTA	Environmental flows and ramp-downs, reduce or minimise maximum dischages, dampen flow fluctuations.
SOCIO-ECONOMIC ISSUES	Dampen flow fluctuations with some major capital works option. Otherwise would need to undertake physical bank protection works, assist with costs of pumps and fencing, and a range of site-specific works.

These options can be divided into three broad groups – water management options (via changes to Poatina power station operations), localised treatment options, and major capital works options.

From the broad options shown in the previous section, a number of specific mitigation options under the three major categories were identified in a series of workshops with key Poatina Basslink researchers. The specific options considered by the Basslink research team are shown below.

Water Management Options

Minimum Environmental Flow
Power Station Ramp-Downs
Reducing Maximum Discharge
Minimising Duration of Full Gate Q

Localised Treatment Options

Bank Protection Works
Bank Revegetation Works
Local Willow Control
River Training Works
Fencing / Stock Exclusion

Major Capital Works Options

Re-regulation Weir
Diversion of Part of Brumbys Flow
Weir Modifications

All of the key downstream Poatina Basslink researchers considered the environmental implications of each option against the discipline they had each assessed. The outcome of this assessment showed that almost any of the above list of options would to some degree effectively mitigate aspects of the Basslink environmental impacts.

The following considerations apply to each of the broad approaches to mitigation of Basslink impacts downstream of Poatina Power Station:

1. The major capital works options were considered to be most effective as a pro-active mitigation measure;
2. Localised treatment works could be effective but was considered a “re-active” approach, repairing downstream environmental damage rather than preventing it. Could be considered in combination with water management options.

3. Water management options could be effective if several of the options are utilised as a package, and especially in combination with localised treatment works, but would not fully mitigate Basslink impacts of the power station. Water management options also constitute significant constraints on the operation of Poatina, and a major capital works option was considered preferable by Hydro Tasmania.

Based on these conclusions, considerable analysis was undertaken into the various capital works options, as they show the most potential to clearly mitigate Basslink impacts.

4.8.5 Detailed Analysis of Major Capital Works Options

As stated previously, significant aims of any Basslink mitigation options are to reduce downstream flow fluctuations; and avoid exposure of macrophyte beds in weir ponds.

Of the three broad types of capital works options listed above, these were broken down into seven very specific options. This involved three different sizes of re-regulation pond, two scenarios for diversion of flow out of Brumbys Creek main channel (over to the Lake River, or to a side channel in Brumbys Creek), and two scenarios for modifications to the existing weir at the Brumbys Creek weir 1 pond (installation of control gates, or extensions to the spillway crest).

These seven options are listed in Table 4.10, along with their effects on downstream flows and water levels in weir 1 pond.

Table 4.10 Analysis of seven capital works options for mitigation of Poatina Basslink issues.

Scenario	Max. Level at No.1 Weir Pond	Min. Level at No.1 Weir Pond	Level Range at No.1 Weir Pond	Max. Flow in d/s Brumbys Crk	Flow Range in d/s Brumbys Crk	Downstream Flow Control*	Change to Minimum No.1 Weir Pond Level*	Land Requirements
Basslink Operations, No Mitigation	0.70 m	0.15 m	0.55 m	55 m^3/s	50 m^3/s			
5.5 Mm^3 Re-regulation Pond	0.47 m	0.36 m	0.11 m	30 m^3/s	10 m^3/s	**80%**	**+ 140%**	**~3.75 km^2**
2.5 Mm^3 Re-regulation Pond	0.50 m	0.33 m	0.17 m	33 m^3/s	15 m^3/s	**70%**	**+ 120%**	**~1.75 km^2**
1.5 Mm^3 Re-regulation Pond	0.53 m	0.31 m	0.22 m	36 m^3/s	20 m^3/s	**60%**	**+ 106%**	**~1.0 km^2**
Flow Diversion to Lake River	0.47 m	0.15 m	0.32 m	30 m^3/s	25 m^3/s	**50%**	**none**	**~0.5 km^2**
Flow Diversion to Side Channel	0.50 m	0.15 m	0.35 m	33 m^3/s	28 m^3/s	**44%**	**none**	**~0.2 km^2**
Extending Spillway Crest at No.1 Weir	0.38 m	0.08 m	0.30 m	55 m^3/s	50 m^3/s	**0%**	**- 47%**	**none**
Control Gates at No.1 Weir	0.40 m	0.10 m	0.30 m	50 m^3/s	40 m^3/s	**20%**	**- 33%**	**none**

***** Compared to Basslink without Mitigation

An analysis of the seven specific mitigation options is shown graphically in Figure 4.13. Figure 4.13. shows the effectiveness of each option in terms of the percent of downstream control over flows compared to Basslink with no mitigation (the yellow bar), and percentage change to the predicted minimum flow level in Brumbys Weir 1 pond due to Basslink with no mitigation (the blue bar). The red dots provide an indication of the cost of each option.

As can be seen from Figure 4.13:

- The works to the crest at Brumbys Weir 1 provide little to no control over downstream flows, and actually reduce the minimum water levels in weir 1 to lower than predicted due to Basslink.
- The diversion options provide some control over downstream flows, but do nothing to mitigate the reduced water levels in the Brumbys weir ponds likely to occur due to Basslink.
- The re-regulation weirs most effectively provide control over downstream flows and increases in the minimum water level in the Brumbys weir ponds. The lowest cost re-regulation pond considered in this analysis was a 1.5 Mm^3 pond, and this option is considered further in the following section.

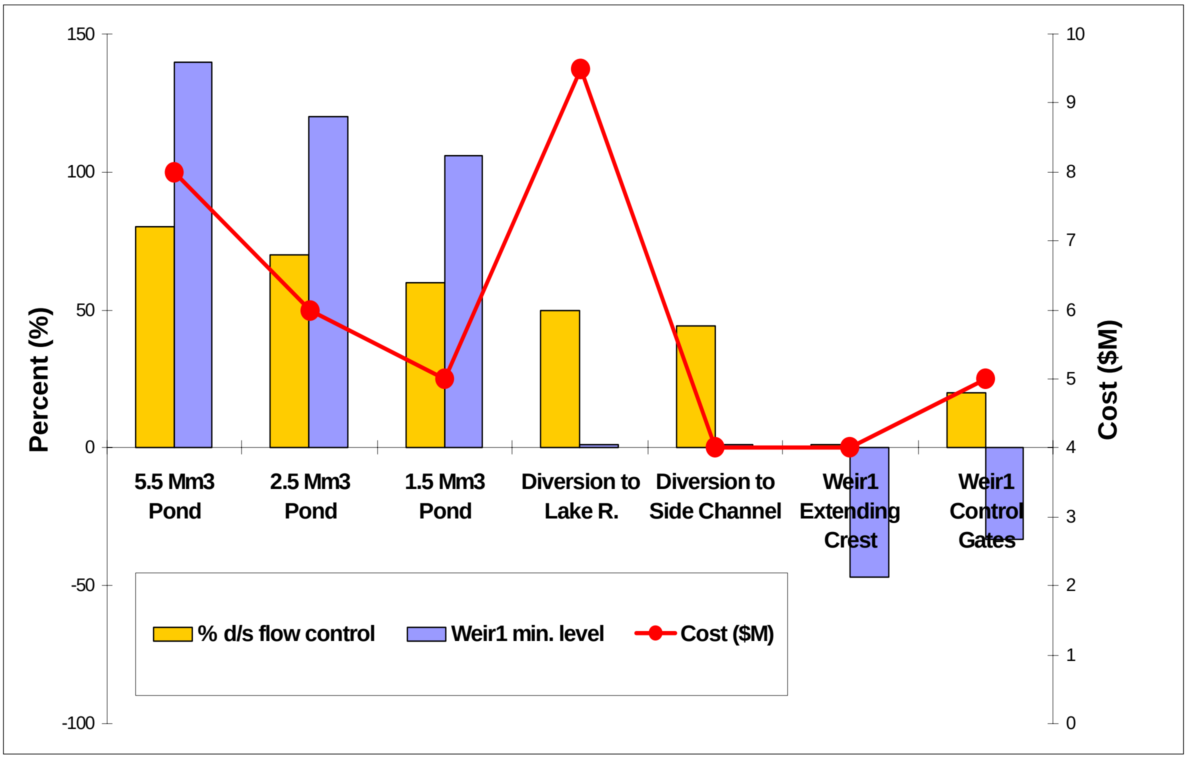


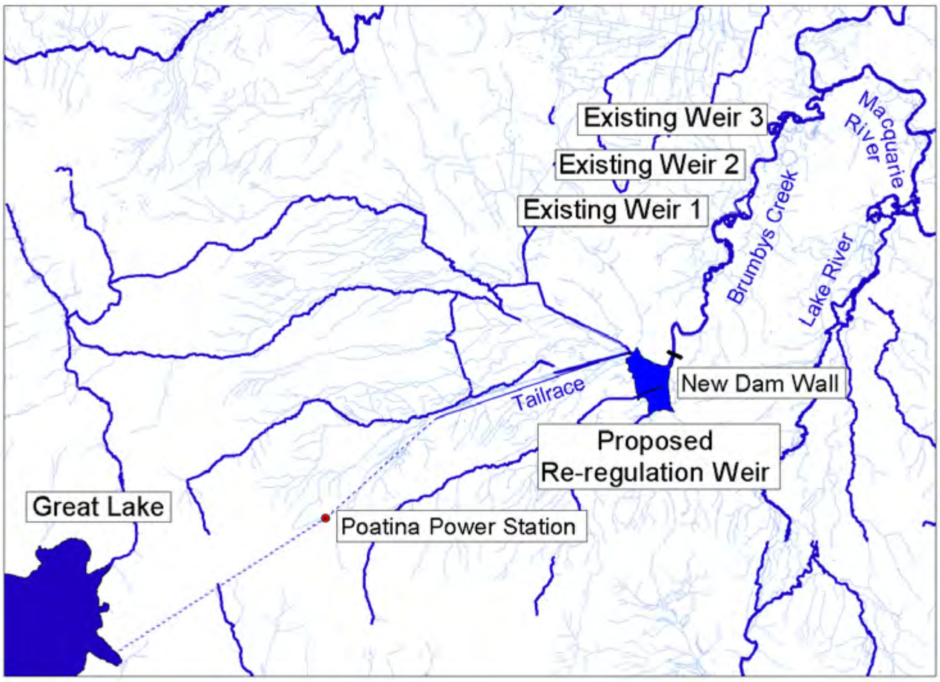
Figure 4.13 Graphical Analysis of Major Capital Works Options to Mitigate Poatina Basslink Issues (percentage change compared to Basslink without mitigation measure)

4.8.6 1.5 Mm^3 Re-regulation Weir

The 1.5 Mm^3 re-regulation weir would be located immediately downstream of the Poatina tailrace, with the weir structure itself approximately 1.5 km downstream of the tailrace, as shown on Map 4.8.

Figure 4.14 shows an overlay of the proposed weir pond onto an aerial photo. High water mark for the pond is shown as a blue line, and low water mark as a solid blue area.

Notable in Figure 4.14 are the inclusion in the weir pond of existing levee banks along that section of Brumbys Creek, and inundation of ground under a transmission line requiring construction of an access causeway. The levee banks and causeway will cause flows to follow the Brumbys Creek channel up to the weir wall, and then inundate areas on either side of the transmission line causeway. The Brumbys Creek channel will be battered back to a stable slope.



Map 4.8 Location of Proposed Poatina Re-regulation Weir

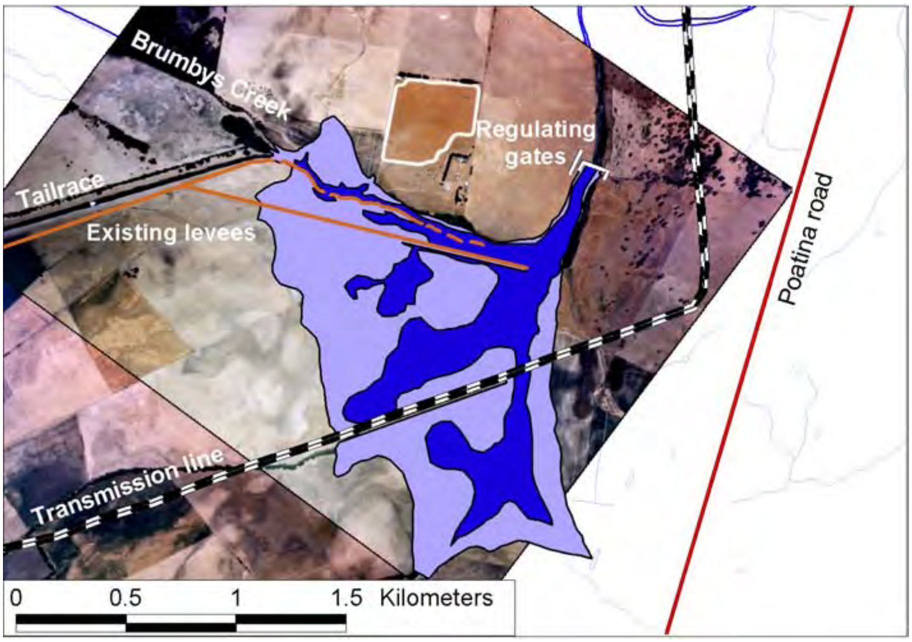


Figure 4.14 Detailed Plan View of Proposed Weir Pond, showing high water (light blue) and low water (dark blue) extents.

Some statistics on the proposed weir are provided in Table 4.11.

Table 4.11 Summary Statistics on Proposed Weir Pond

Land Area at HWM	1.75 km^2
Effective Pond Capacity	1.7 Mm^3
Dam Height	8 m
Dam Embankment Length	~100 m
Depth of Pond	3.5 m max.
Water Level Range in Pond	1.5 m
Effective Residence Time	6-12 hours
5 radial gates, capacity	150 m^3/s
Spillway capacity	350 m^3/s
Percent of flow controlled	~60%
Downstream flow range	~15-35 m^3/s

Figure 4.15 provides a picture of the effectiveness of the proposed weir in dampening downstream flow fluctuations.

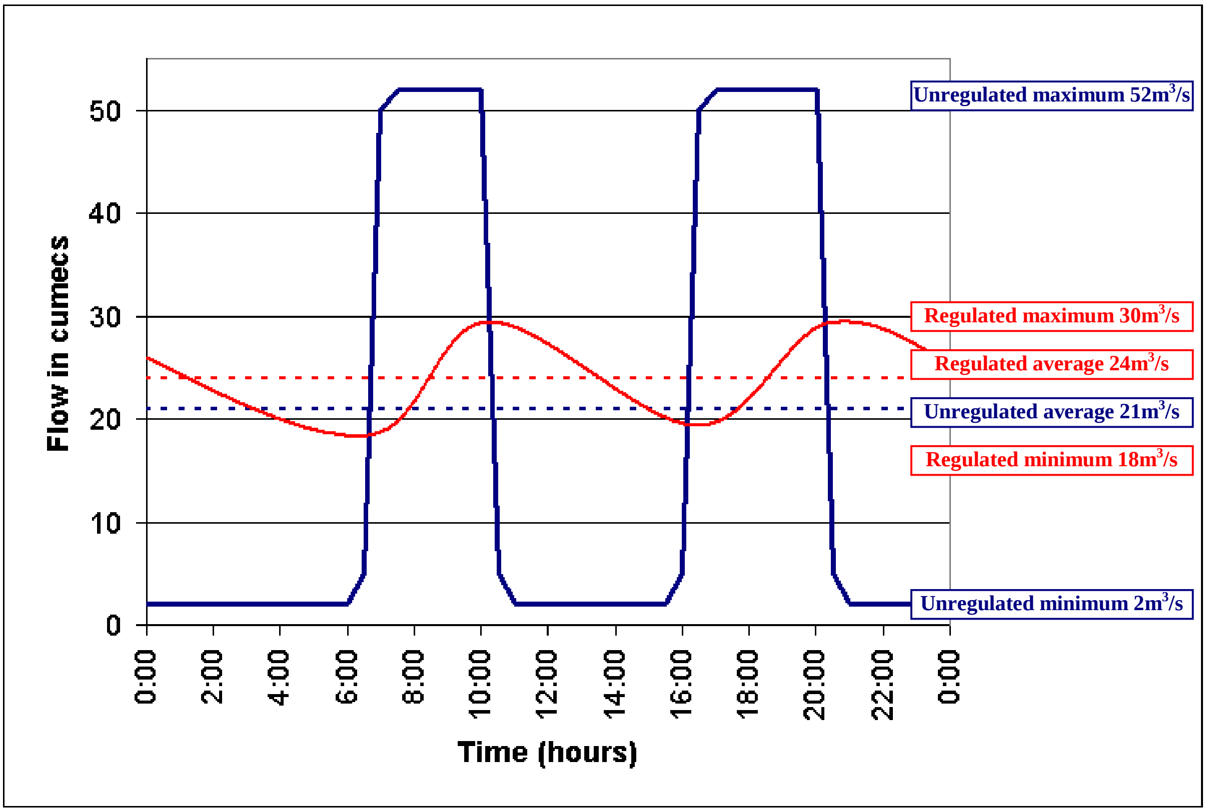


Figure 4.15 Dampening of Downstream Flows Provided by Proposed Re-Regulation Weir Downstream of Poatina Power Station

4.8.7 Hydro Tasmania Basslink Commitments for Downstream Poatina Power Station

Hydro Tasmania commits to construction of a 1.5 Mm^3 capacity re-regulation weir downstream of the Poatina tailrace as a measure to accompany the Basslink development and ensure mitigation of environmental impacts downstream of the Poatina Power Station. The environmental control pond is intended to be operational at the time of commencement of Basslink operations.

The re-regulation weir, combined with a comprehensive monitoring program, comprise the package of mitigation options to which Hydro Tasmania will commit if the Basslink development proceeds.

4.9 Poatina Basslink Monitoring

4.9.1 Overview

This section considers what monitoring activities will continue to be undertaken if the Basslink project is approved. The purpose of the monitoring program is to establish the existing conditions downstream of the Poatina Power Station; assess the changes (short- or long-term) caused by Basslink operations; and determine the effectiveness of any mitigation measures applied.

A considerable number of hydrological monitoring sites, both present and historical, exist for the area downstream of Poatina. A number of these were established for the hydrology study summarised in Section 4.2.1. The locations of the hydrological monitoring sites downstream of Poatina are listed in Table 4.2. It will be important for future Basslink monitoring that comprehensive hydrological data continue to be available.

The following sections list, firstly, the proposed monitoring program and, secondly, provide a discussion of possible future studies.

4.9.2 Poatina Basslink Monitoring Program

The Poatina Basslink Monitoring Program, which will be included in the Basslink mitigation package, will include elements of water quality, fluvial geomorphology, riparian vegetation, and macroinvertebrates. The proposed program will include monitoring of channel cross sections, and the development of a macroinvertebrate monitoring program, pre-Basslink. These activities will be repeated 2 and 5 years post-Basslink. As well, a five and ten year post-Basslink aerial photography program will be undertaken.

Almost all of the elements to be monitored will rely on accurate hydrological data for analysis of monitoring results. It will be necessary to retain the existing permanent hydrological monitoring stations and the recently installed temporary stations should be maintained for the duration of the major elements of the monitoring program.

Most of the suggested **water quality** monitoring is presently being carried out under the Waterway Health Monitoring Program (see Section 4.2.3.10), and will be continued pre- and post-Basslink.

Fluvial geomorphology monitoring (see Section 4.3.6) should include channel cross-section measurements, performed once pre-Basslink and at 2 and 5 years post-Basslink, and riparian vegetation monitoring using aerial photography at 5 and 10 years post-Basslink, to facilitate comparison with the most recent aerial photographs. The aerial photography should also be assessed to determine if it is useful for determining the distribution of, and changes to, aquatic and semi-aquatic weeds, and weir pool morphology.

Some measure of the reaction of the **instream biota** (Appendix 18) downstream of Poatina to the Basslink-modified conditions and the mitigation measures undertaken will be needed. To develop and effective monitoring program, an initial assessment of the macroinvertebrate community should indicate the pattern of macroinvertebrate abundance and diversity across habitat types, locations and seasons, and the minimum number of samples from each of these strata which are required to assess future changes, with a given sensitivity. An initial, intensive survey should be followed by routine monitoring every 2-3 years using the quantitative sampling design determined above, in order to assess changes in macroinvertebrate abundance and diversity which result from Basslink operations, and any mitigation measures undertaken. This work should include selection of appropriate control sampling locations (and strata) for assessing changes in lower Brumbys Creek and the lower Macquarie and South Esk Rivers caused by Basslink operations.

The Poatina Basslink Monitoring Program will form an integral part of the Basslink Monitoring Program. The cost of the proposed program will vary from year to year, depending on the work to be done. For the first year (ie pre-Basslink monitoring) the cost is estimated to be in the order of $44,000.

Table 4.12 lists the approximate schedule and activities required for each visit, for each monitoring element.

4.10 Conclusions from Downstream Poatina Investigations

The downstream Poatina environmental investigations for the Basslink development have provided considerable data documenting modifications to the river channel due to existing power station operations and surrounding land use practices, particularly in Brumbys Creek. The Basslink development alters the historical operating patterns of the Poatina Power Station, which in turn will result in some further adjustments to the downstream waterways, most particularly in Brumbys Creek.

Basslink changes to the waterways downstream of the Poatina Power Station, in the absence of mitigation measures, are anticipated to cause continued channel degradation with changes in mechanisms particularly in Brumbys Creek, increased stresses to instream biota particularly in Brumbys Creek, as well as exacerbate existing problems with pump set-ups and stock stranding. As a consequence of the understanding of environmental processes obtained from these investigations, the Basslink project will be accompanied by a major riverine enhancement measure for the waterways downstream of Poatina, accompanied by a monitoring program.

The construction of a re-regulation wier will function as an environmental control pond downstream of the Poatina tailrace. There is believed to be sufficient understanding from the research undertaken to support the conclusions presented in this report, and to support that the proposed environmental control pond is the optimal mitigation measure. A workshop of key Poatina Basslink researchers concluded that the 1.5 Mm^3 re-regulation pond is an excellent option to mitigate Basslink impacts, and that the level of control it provides over downstream flows should adequately control the peak flows out of the Poatina Power Station. This option not only fully mitigates Basslink impacts, but also addresses to some degree environmental concerns with existing Poatina operations.

The estimated cost to Hydro Tasmania is greater than $5.5 million dollars, or $400,000 annualised.

The focus of any further investigations, covered by the proposed Basslink monitoring program, is to supplement the baseline data obtained in these investigations and then document changes to the downstream ecosystem as a result of the Basslink project with the environmental control pond in place.

An assessment of the Basslink project after allowing for implementation of the proposed mitigation measures concludes that Basslink will not cause further degradation of the waterways downstream of Poatina Power Station. As with the Gordon River mitigation measures, the Basslink development provides the financial framework within which Hydro Tasmania can make such a signficant environmental commitment. As a consequence of the environmental control pond, the waterways downstream of Poatina will see substantial environmental improvement if the Basslink development is approved. Hydro Tasmania's monitoring commitment will enable assessment of the success of the mitigation measure, and allow refinements to discharge regimes from the environmental control pond to be undertaken if required in the future.

Table 4.12 Summary of Poatina Basslink Monitoring Program Activities

Element	Parameter	Location	Frequency	Timing	Notes
Hydrology	stage height	See Table 4.1	continuous		sites should be maintained for the duration of the monitoring program
Water Quality	Water temperature, dissolved oxygen	PS tailrace	continuous		site should be maintained for the duration of the monitoring program
Fluvial Geomorph.	aerial photography	Brumbys Creek, downstream reaches of the Macquarie and South Esk Rivers	5 & 10 years post-Basslink	PS shut-down	verify that riparian vegetation, as well as aquatic and semi-aquatic macrophytes and weir pool morphology are able to be assessed using this method
	channel cross sections	Gerke's cross sections	once pre- and 2 & 5 years post-Basslink	PS shut-down	
Riparian & aquatic veg., weir pool morphology	aerial photography	Brumbys Creek	5 & 10 years post-Basslink	PS shut-down	compare with results of present study
Macroinverts.	study design (sample size, etc), abundance and diversity across habitat types, locations and seasons	lower Brumbys Creek, lower Macquarie & South Esk Rivers; appropriate control sampling locations (and strata)	initial intensive survey, pre-Basslink; monitoring 2 & 5 years post-Basslink	Oct or April	

5 DOWNSTREAM JOHN BUTTERS POWER STATION INVESTIGATIONS

Section 5 begins with background information on the King River catchment area and the John Butters Power Scheme (Section 5.1).

Sections 5.2 to 5.7 present the outcomes of the environmental assessment of Basslink impacts on each of the major headers required for assessment in the Basslink Integrated Impact Assessment Statement:

Sec. 5.2 - Surface Waters (hydrology, water quality),

Sec. 5.3 - Land (fluvial geomorphology),

Sec. 5.4 - Groundwater,

Sec. 5.5 - Flora and Fauna (instream biota, terrestrial biota),

Sec. 5.6 - Estuarine Issues (Macquarie Harbour), and

Sec. 5.7 - Socio-Economic Issues (cultural heritage, visual amenity, public use and safety, industries affected and economic impacts).

Section 5.8 summarises the investigations downstream of the John Butters Power Station, identifies Basslink issues, and proposes mitigation options.

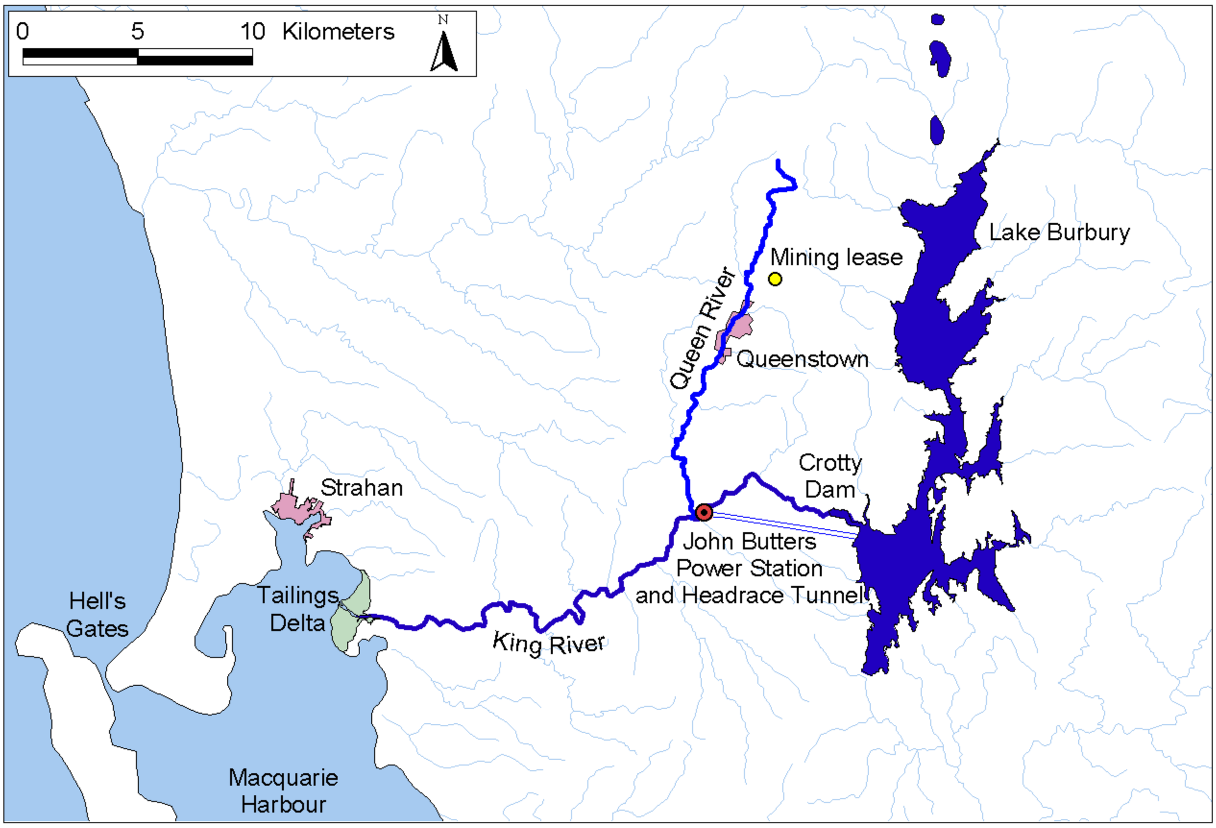
Section 5.9 presents the proposed Basslink monitoring program for downstream of John Butters Power Station.

5.1 Background Information on Catchment

5.1.1 Catchment Characteristics

The King River catchment covers 809 km^2 in western Tasmania. Approximately 650 km^2 of this catchment drains into Lake Burbury, the storage created for power generation from the John Butters Power Station (Map 5.1). The Eldon, South Eldon, Governor, Nelson and Tofft rivers all feed into Lake Burbury. The Queen River is the only major tributary downstream of the John Butters Power Station.

The catchment area as a whole is unpopulated and undeveloped except for the power development, the township of Queenstown, forestry operations, tourism activities, recreational fishing in Lake Burbury, and the Mount Lyell copper mine. The north and eastern parts of the catchment are national parks included in the Tasmanian Wilderness World Heritage Area. Land tenure in the vast majority of the catchment is unallocated Crown Land and State Forest.



Map 5.1 Lower King River and Environs

The main geomorphological feature of the King River catchment is the West Coast Range, which runs parallel to the coast and consists of long mountain ridges separated by broad valleys. Resistant siliceous Ordovician conglomerate forms the prominent ranges, and erodible Precambrian and Cambrian sandstones and shales with dolomite and conglomerate horizons underlie the valleys and plains. Ordovician, Devonian and Silurian sandstones, mudstones and limestones outcrop along much of the King River valley. Pleistocene glacial deposits and features cover the geology of the area.

Vegetation is dominantly dense temperate rainforest and buttongrass moorland and wet scrub. The rainforest contains species such as Blackwood, Myrtle and King Billy Pine in the upland regions, and Huon Pine prevalent along the watercourses.

Rapid uplift of the moist airstream over the West Coast Range results in rainfall averaging more than 2,500 mm annually at Queenstown.

The King River discharges into Macquarie Harbour near the township of Strahan. Strahan has a very successful tourism industry, and is the base for a successful and growing aquaculture industry in Macquarie Harbour.

The Mount Lyell copper mine has continuously operated for over one hundred years, and is the primary industry supporting the township of Queenstown (see mining lease in Map 5.1). The historical mine practices of direct discharge of mining wastes into the Queen River (an estimated 97 million tonnes of fine-grained tailings, as well as smelter slag) have resulted in substantial accumulations of mine waste sediments in the bed, banks and delta of the King River. Because of sulphidic rock exposed on the mine lease site, copper, aluminium and zinc present in the rock are liberated due to the creation of acid drainage, and are present in high concentrations in the run-off from the lease site.

The Mount Lyell mine used to operate an Abt railway between Queenstown and Strahan, which is at present being redeveloped as a tourism venture. A tourist drive along the King River approximately 5 km from the mouth to an old iron railway bridge known as the Teepookana Railway bridge was a popular activity for Strahan-based tourists, until its closure due to the Abt Railway redevelopment. A tourist jet boat ride from Strahan goes to upstream of the Teepookana Bridge, and provides commentary on many aspects of the river including the history, surrounding rainforest, environment and heritage. The Forestry Commission maintained the existing roads along the King River, and has an active program of salvaging fallen Huon Pine on the Teepookana Plateau. Access to the Plateau once the Abt Railway has been constructed has not been finalised, but is expected to be river-based.

Macquarie Harbour is a 297 km^2 enclosed embayment which receives the flows from the King and Gordon rivers. These rivers are the major freshwater inputs and influence on harbour circulation patterns. The water quality of the harbour is controlled by the complex interactions of the highly contaminated King River water, and the pristine seawater and high quality Gordon River water. Copper, aluminium and other metals all enter the harbour from the King and are dispersed by wind mixing and currents. Production of Ocean (rainbow) Trout and Atlantic Salmon is a major industry in Macquarie Harbour, and the largest threat to this industry is the poor water quality introduced to Macquarie Harbour via the King River.

5.1.2 The John Butters Power Scheme

The King River Power Development was authorised by Parliament in 1983. The two dams in the scheme, Crotty Dam across the King River and Darwin Dam at Andrew Divide, were completed in 1991. Lake Burbury reached full supply level in 1992, allowing the John Butters Power Station to be commissioned in February of that year.

Water is transferred from Lake Burbury near Crotty Dam to the power station via a 7 km tunnel below Mount Jukes, producing a 199 m head. The power station houses a single Francis generator with a capacity of 143 MW. The John Butters Power Station discharges into the King River approximately 8 km downstream of Crotty Dam, and 700 m upstream of its confluence with the Queen River. The long-term average power output from the station is 61.5 MW.

Unlike the Gordon and Poatina power stations, John Butters is most commonly operated to provide ‘step load’ or ‘frequency’ demand. Frequency is the additional daily load above base and step load (see Section 2.1) that constitutes the remainder of the daily load curve. Power stations operating to provide frequency demand vary their generation within a particular range to meet the fluctuations of the daily load curve, and discharge from these power stations tends to be variable over very short periods.

Efficient load from the John Butters Power Station equates to a power station discharge between 75-82 m^3/s, and full capacity discharge between 84-87 m^3/s, depending on water levels in Lake Burbury.

Lake Burbury has a surface area of 53 km^2 at full supply level, has a reservoir capacity of 1,065 Mm^3, and an approximate depth of 80 m at the Crotty Dam. The operating range is approximately 9 m, and the intake depth is 37.1 m below full supply level.

5.2 Environmental Assessment of Surface Water Impacts

This section looks at environmental information on the hydrology and water quality downstream of the John Butters power station, in relation to present status and potential Basslink changes.

5.2.1 Hydrology

A summary of hydrological information on Lake Burbury and John Butters Power Station operations for historical operations and predicted Basslink changes is provided as Appendix 22.

5.2.1.1 Lake Levels

Lake Burbury operating range varies 9 metres, between 226 and 235 m ASL. The historical record for Lake Burbury spans the period 1991 to 1998, including the period of lake filling. TEMSIM modelling of Lake Burbury lake levels predicted lower than historical lake levels, as shown in Figure 5.1 and Figure 5.2, but this could be accounted for by the short and relatively wet period of historical record and possibly also lower loads on the system. The Basslink scenario tends to draw Lake Burbury storage down by approximately two metres and hold it there for a greater amount of time compared to the historical record. The seasonal fluctuations in lake levels is similar between Basslink and historical conditions (Figure 5.3). Decreased variability in lake levels under a Basslink regime is illustrated in Figure 5.4.

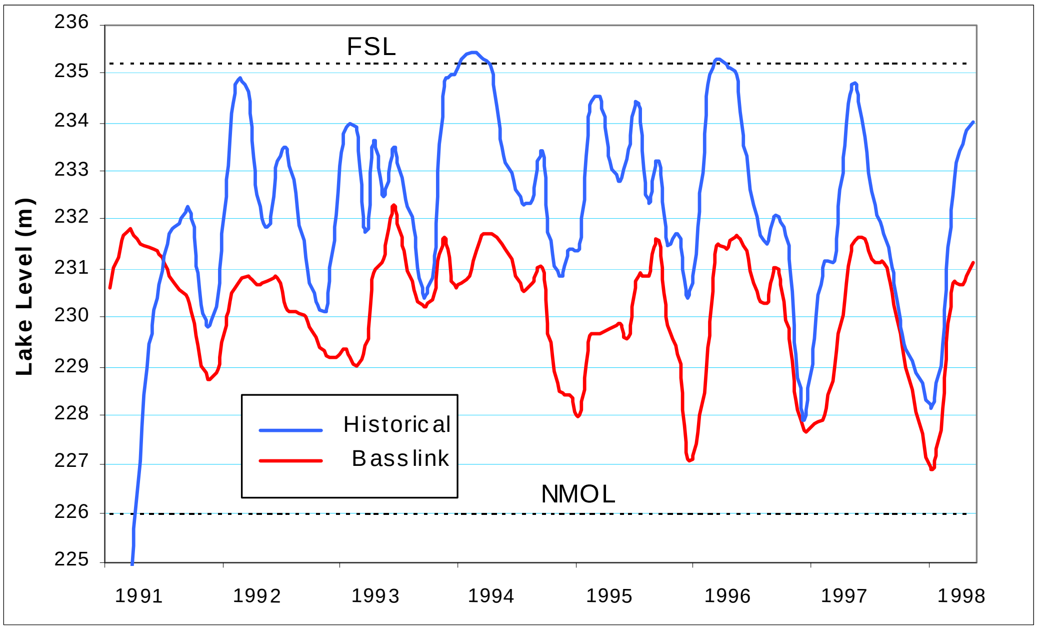


Figure 5.1 Lake level time series plot for Lake Burbury

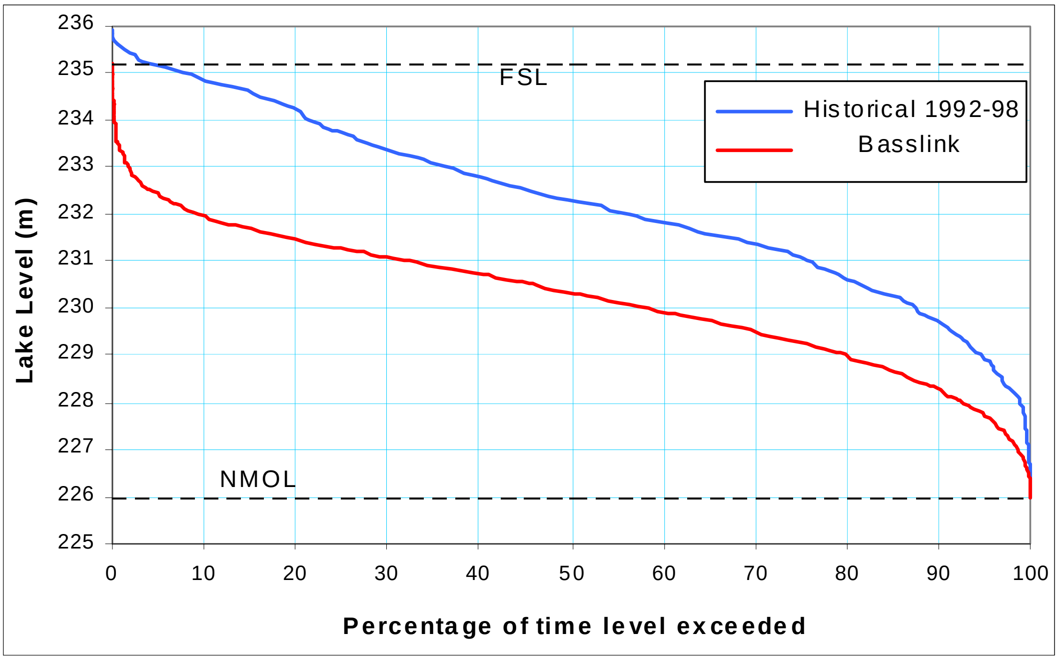


Figure 5.2 Lake level duration plot for Lake Burbury

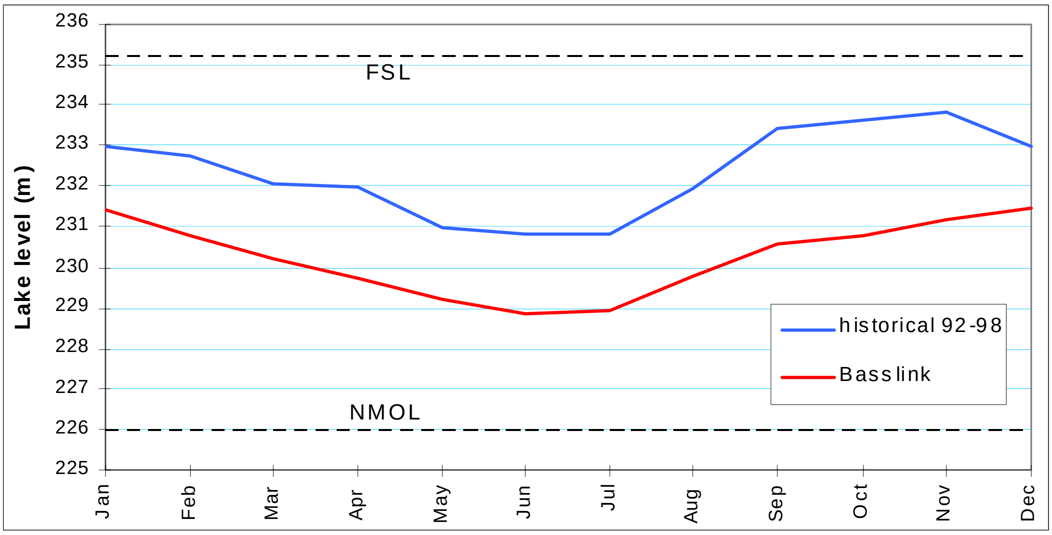


Figure 5.3 Average monthly lake levels for Lake Burbury

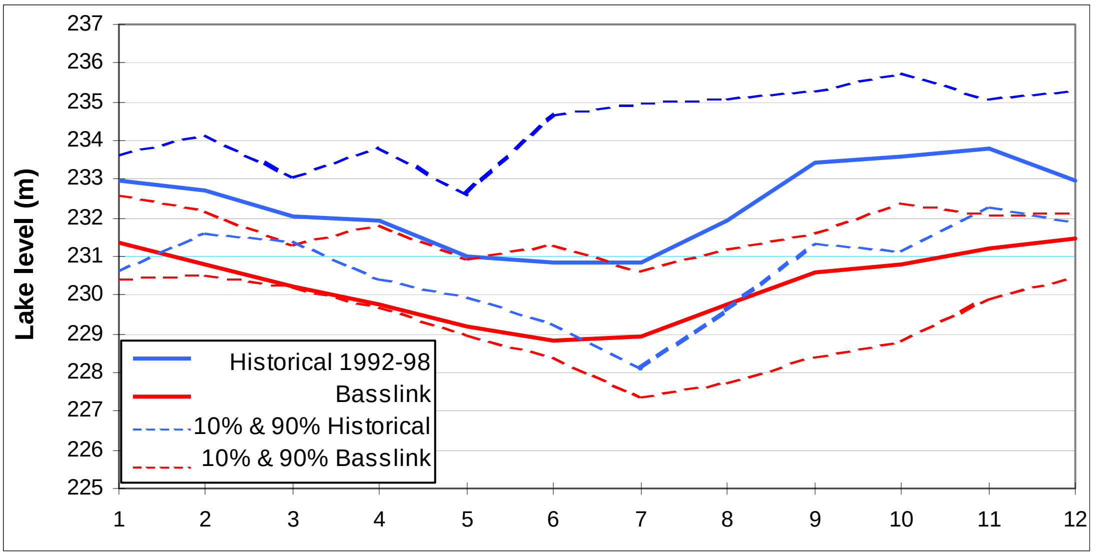


Figure 5.4 Mean, 10th and 90th percentile monthly Lake Burbury levels for Basslink and Historic scenarios

5.2.1.2 Power Station Discharges

Figure 5.5 shows time series plots for the John Butters Power Station during a wet year (1994), and Figure 5.6 shows a dry year (1995) for historical operations and Basslink. Figure 5.7 shows a comparison of historical and Basslink monthly median flows for the period 1992-1998. Notable differences from the three figures are the increased on-off operation of the power station with Basslink compared to historical conditions, and under Basslink there is more consistent and higher discharge periods in winter than in summer. Basslink operation of the power station shows a strong uni-modal peak during the winter months.

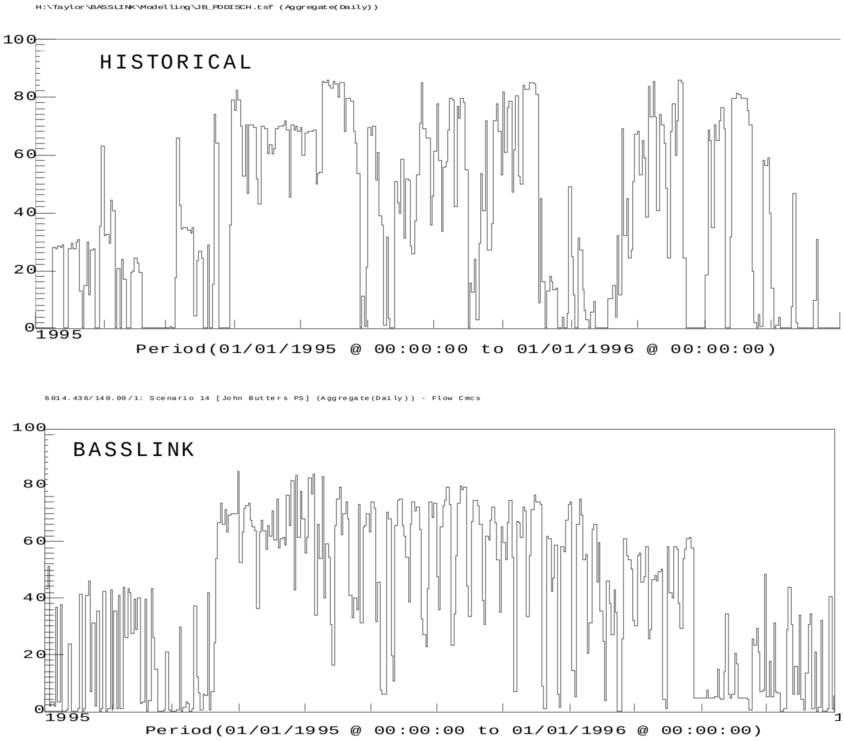


Figure 5.5 Average daily discharge time series plots for John Butters Power Station during a wet year (1994)

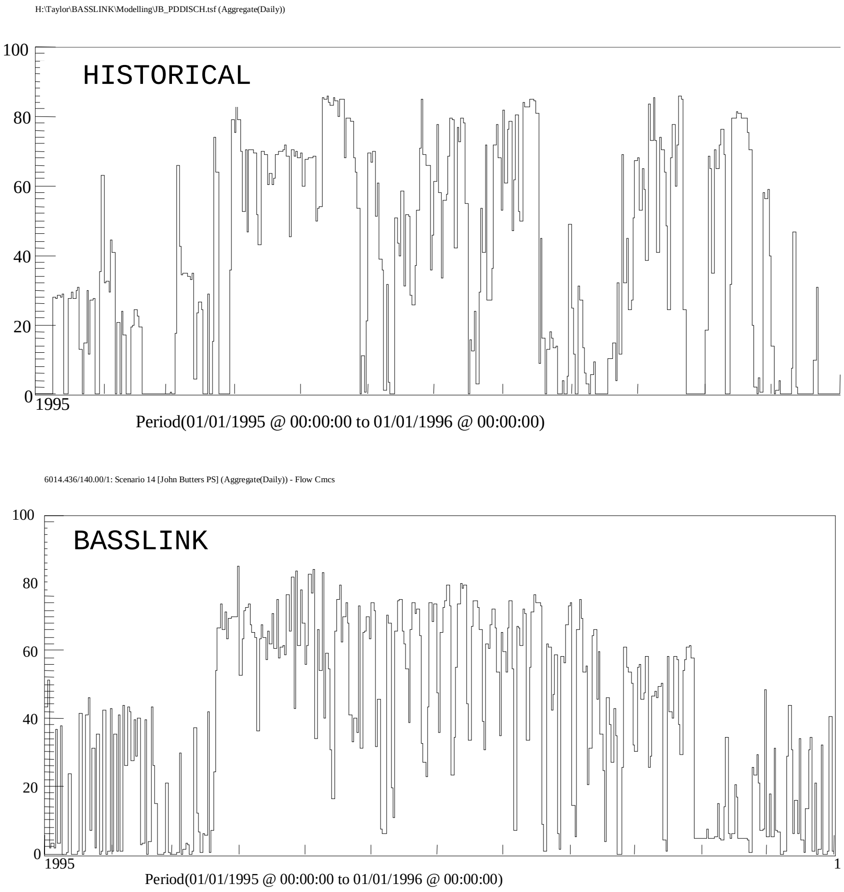


Figure 5.6 Average daily discharge time series plots for John Butters Power Station during a dry year (1995)

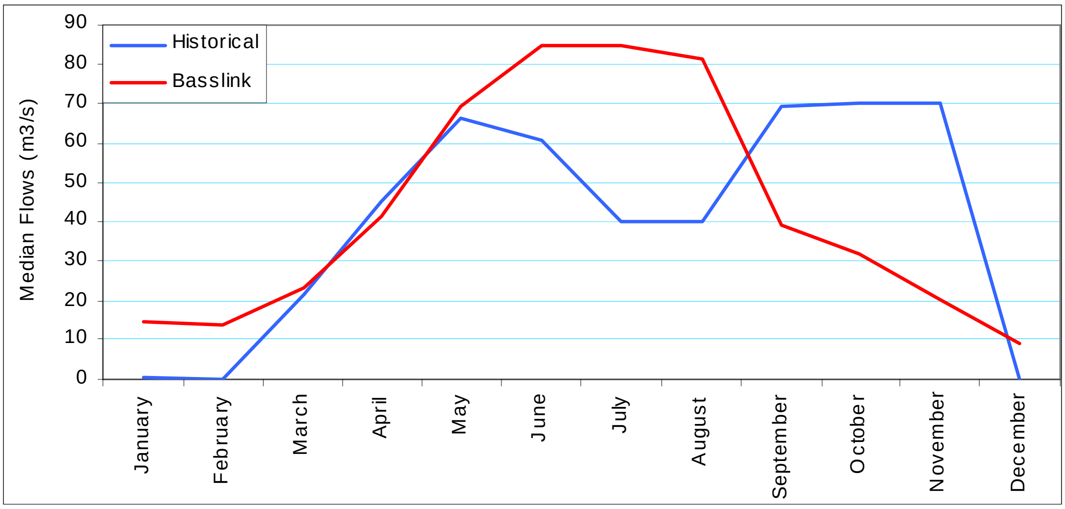


Figure 5.7 Monthly median flows from the John Butters Power Station, 1992-1998

Table 5.1 shows summary statistics comparing actual and simulated hourly flow records at the John Butters Power Station, using data from 1997-98.

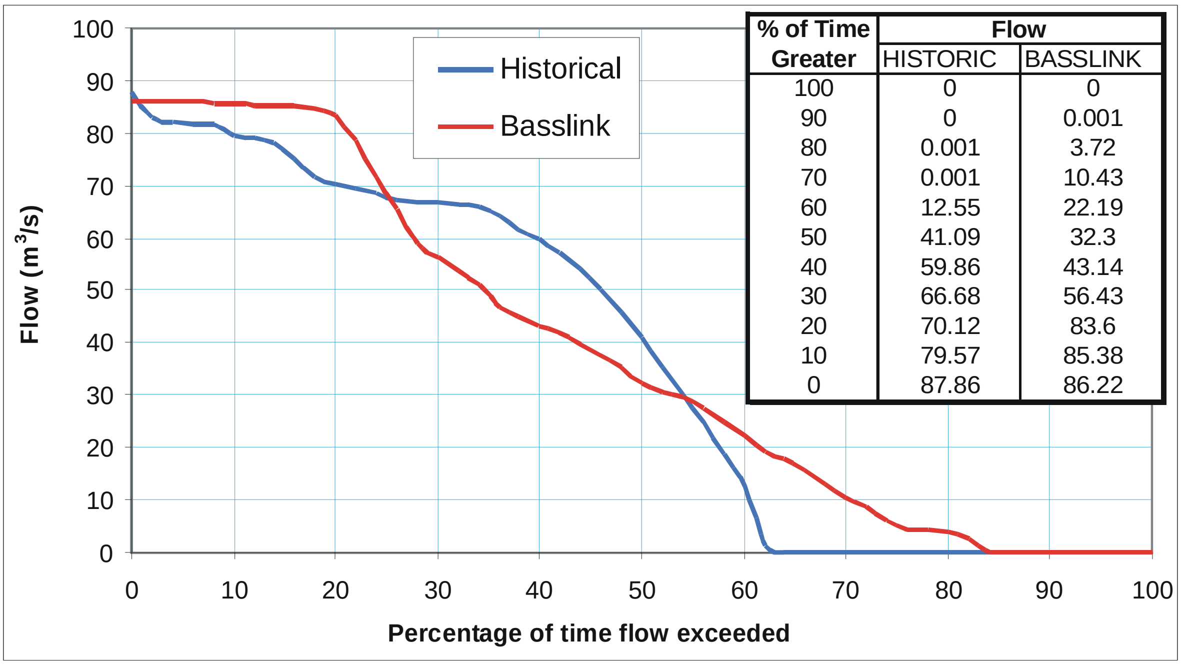
Table 5.1 Comparison of Actual and Simulated Daily Flow Records at the John Butters Power Station using <u>Hourly</u> Data (1997-1998)

STATISTICS	HISTORICAL OPERATION OF POWER STATION [1]		BASSLINK OPERATION OF POWER STATION	
Mean flow (m^3/s)	36.1		36.4	
Annual Mean Minimum Flow 1 Hour Minimum (m^3/s) 7 Day Minimum (m^3/s)	 0 0		 0 2.2	
Annual Mean Maximum Flow 1 Hour Maximum (m^3/s) 7 Day Maximum (m^3/s)	 86.1 79.2		 86.2 77.3	
Ave. Number of Annual Events	Flow	No. Events	Flow	No. Events
-Greater than mean flow	36.1	222	36.4	368
-Power station shutdown	0	83	0	192

Table 5.1 shows that mean flows from the John Butters Power Station are similar (36 cumecs). The increase in the number of annual discharge events greater than the mean flow and in zero discharge events changes significantly, with an increases from 222 to 368 annual discharge events greater than the mean flow with Basslink, and an increase in the number of shutdown events from 83 to 192 each year.

The flow duration for John Butters power station derived from TEMSIM modelling shows a greater peak loading and more low flows than the historic operation of the station (Figure 5.8). The attached table provides a more detailed picture of the percent of time particular flows are exceeded under

Basslink compared to historical operations. Flows of 40-60 m^3/s are exceeded less under Basslink, whereas flows of 70 and 80 m^3/s are exceeded a greater percent of the time under Basslink.



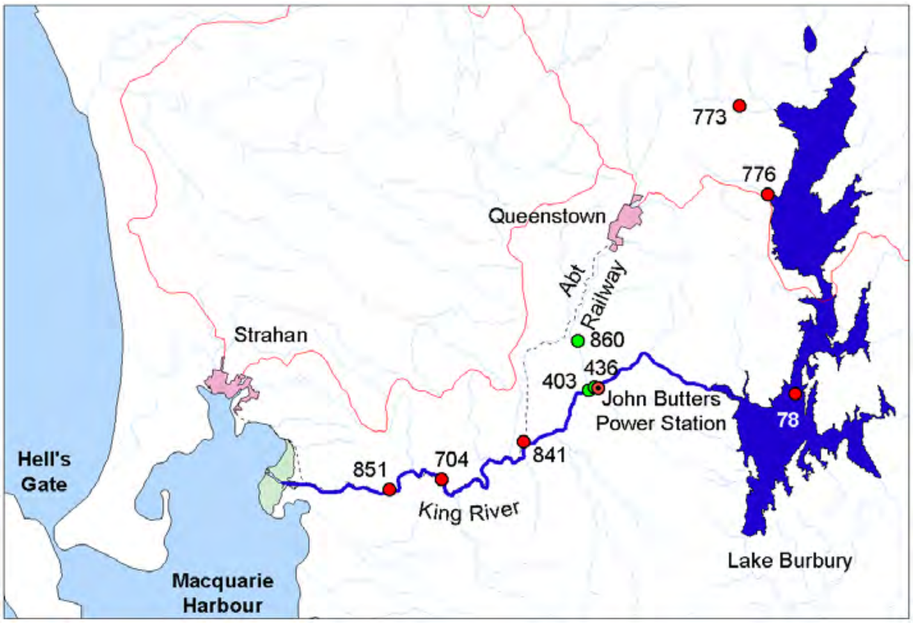
% of Time Greater	Flow	
	HISTORIC	BASSLINK
100	0	0
90	0	0.001
80	0.001	3.72
70	0.001	10.43
60	12.55	22.19
50	41.09	32.3
40	59.86	43.14
30	66.68	56.43
20	70.12	83.6
10	79.57	85.38
0	87.86	86.22

Figure 5.8 Flow Duration Curves for John Butters Power Station Discharge during Historical and Basslink Operations (hourly data, 1997-98)

Appendix 22 shows that under Basslink it is predicted that the number of 16-32 hour release events increases substantially, and there is some increase in the number of 2-6 hour events compared to historical operations. There is also predicted to be an increase in the number of 24 hour shutdowns and the number of 2-6 hour shutdowns with Basslink compared to historical operations.

5.2.1.3 Downstream Propagation of Power Station Discharges

Map 5.2 shows the King River downstream of the John Butters Power Station. The power station discharges into the King River 350 metres upstream of Newall Creek. The most significant tributary downstream of the power station is the Queen River, which enters on the right bank 0.7 km downstream of the power station and has a median flow of 1.4 m^3/s. Also on Map 5.2 are the locations of hydrological monitoring data in the King River downstream of the John Butters Power Station. Green dots show monitoring stations currently active, and red dots show locations of historical data. Time periods for data available from each station are provided in Table 5.2.



Map 5.2 Hydrological sites along King and Queen Rivers

Table 5.2 Hydrological Sites in the King River Region.

Site No	Site	Location	Start of Record	End of Record
78	King River	at Crotty	1924	1995
403	King River	below Queen River	1991	Present
436	John Butter P.S. Discharge	Energy (MWh)	1992	1997
436	John Butter P.S. Discharge	Power (MW)	1996	Present
704	King River Environmental	Site No. 13	1994	1996
773	Comstock Creek	above King River	1978	1995
776	Linda Creek	above King River	1978	1979
841	King River	below Sailor Jack	1985	1995
851	King River	Below Cutten Creek *	1986	2000
860	Queen River	Below Lynchford	1986	Present

* Not rated to flow – tidal influence

The flow records chosen for flow analysis (based on location, length and accuracy of record and available rating data) are shown as shaded

An analysis of propagation of power station discharges downstream of the power station (Table 5.3) shows that water level varies between 1.8 and 0.8 m at the downstream sites, and it takes more than 5 hours after the power station turns off for water levels to fully drop at the King River at Cutten Creek (within 3 kilometres of the river mouth). It is anticipated that the succession of shorter duration on-off events as modelled under Basslink will to some degree further dampen the range of water level changes experienced at the downstream sites.

Table 5.3 Downstream Water Level Fluctuations to On – Off Operation of John Butters Power Station (13/7/94 – 14/7/94)

(Note: all times are in decimal hours)	**John Butters Power Station Shutdown[1]**		**John Butters Power Station Turn On[1]**		
	Lag time in start of drop	*Time taken to drop*	*Lag time in start of rise*	*Time to rise*	*Water Level Change (m)*
King River below Queen River	<<1	1.25	<<1	0.5	1.8
King River below Sailor Jack	1	2	1	1	1.2
King Environmental Site No. 13	2	3.25	2	2.25	1.2
King River below Cutten Creek	2	5.25	2	2.5	0.8

[1] This table is based on a 70 cumec discharge event (efficient load) from the Power Station
[2] Tidal influence at this site

5.2.1.4 Summary of Basslink Hydrological Changes

In summary, under Basslink for the John Butters Power Station there is an increase in the occurrence of full capacity discharge (likely to be over-estimated), an increase in the number of on-off events in a given year, and a seasonal shift in power station discharges. Note that there is no increase in the maximum release capacity of the power station, as this is limited by the generator capacity. Rates of river level rise and fall at the power station will not change due to Basslink, although attenuation downstream may change with increased on-off operation.

5.2.2 King River Water Quality

5.2.2.1 Background and Available Data

The King River water quality assessment was undertaken by Koehnken and is presented in full in Appendix 23 of this report series. This report was a desktop study summarising the very large existing information base on King River water quality. Appendix 23 provides a systematic assessment of the implications of Basslink on all of the key indicators for Water Quality Objectives provided by the Department of Primary Industries, Water and the Environment (DPIWE).

Considerable information exists because of extended and in-depth water quality monitoring in the waters affected by the Mount Lyell Copper Mine in Queenstown. Because of the sulphidic rock exposed on the lease site, copper, aluminium and zinc present in the rock, and acidity, are liberated through the creation of "acid drainage" (AD), and are present in high concentrations in the run-off from the lease site. The vast majority of the metal-laden acid drainage runs into the Queen River, a major tributary of the King River which meets the King less than one kilometre downstream of the John Butters Power Station (see Map 5.2).

Prior to the creation of Lake Burbury, Hydro Tasmania undertook comprehensive investigations of the water quality and toxicity of the run-off from the Mount Lyell lease site which would enter Lake Burbury, and as a result put in place diversion works in 1991 to reduce inflows from Linda and

Comstock Creeks into the newly formed lake. This has significantly reduced the levels of copper draining into Lake Burbury.

Since filling of Lake Burbury, the Inland Fisheries Service and Hydro Tasmania have undertaken water quality surveys of Lake Burbury, and this data has been available for review.

Considerable water quality data on the Queen River and the lower King River below the John Butters Power Station have also been collected as part of the King River – Macquarie Harbour Environmental Studies in 1993-1994, and the Mount Lyell Remediation Research and Development Program in 1995-1996. More recent investigations by Hydro Tasmania have examined how metal and sediment levels in the river change as water levels increase.

Dissolved oxygen data is available from the power station, because air injection is currently used as a mitigation measure to address low oxygen levels in water taken from Lake Burbury. The power station off-take is 37.1 m below the full supply level of the lake, and the lake profiles have shown thermal stratification of the lake during the summer months. Several months after commissioning of the power station, in April 1992, water containing low dissolved oxygen levels and elevated organic material was observed in northern Macquarie Harbour, and traced back to the power station. Air injection has been employed on a seasonal basis since this time to increase D.O. concentrations from < 2 mg/L to > 6 mg/L in the power station discharges.

5.2.2.2 Present Water Quality Immediately Downstream of the Power Station

Because of the utilisation of air injection at the power station and the diversion works at Linda and Comstock Creeks, water quality passing through the John Butters Power Station is of adequate quality.

Downstream of the power station but upstream of the Queen River, monitoring of water released from the power station shows smaller seasonal temperature changes compared to an unregulated Tasmanian West Coast river. When the power station is shut down, the water temperature quickly returns to more seasonal water temperature values. Dissolved oxygen levels show a strong response to power station operation, with fluctuations in D.O. concentrations in summer due to low D.O. from Lake Burbury and the utilisation of air injection from the power station. Conductivity and turbidity values show small fluctuations in response to power station operation, but are generally very low values.

5.2.2.3 Present Water Quality Downstream of the Queen River

The Queen River delivers approximately 2000 kg/day of dissolved copper to the lower King River. Copper and aluminium are the primary metals limiting biological activity, but zinc is also toxicologically significant under certain flow conditions. Dissolved copper concentrations of up to 5 mg/L have been recorded in the lower King River, many times exceeding the ANZECC (1992) Guidelines for protection of aquatic ecosystems of 5 µg/L. The effects of this extremely poor water quality on the instream biota are well-documented, as summarised in Appendix 25 of this report series (see Section 5.5.2 of this report).

The John Butters Power Station is a major diluent of metal concentrations in the lower King River. The dilution provided by the King River relative to the Queen River is approximately 3-fold when the power station is off, increasing to approximately 18-fold when the power station is on (based on mean Queen River flows and power station efficient load).

The worst case scenario for downstream water quality under existing conditions is when the power station is shut down for an extended period, and rainfall on the Mount Lyell lease site delivers high concentrations of copper into the King River. Under these circumstances, a “mass” of copper-laden water collects in the King River downstream of the Queen River tributary, and when the power station comes back on line this mass is pushed out into Macquarie Harbour creating a copper-rich plume. Such a plume is of great concern to the growing aquaculture industry in Macquarie Harbour. Marine farming operations are currently restricted to the central and western parts of the harbour because of water quality concerns.

5.2.2.4 Remediation Efforts at Mount Lyell

The Mount Lyell Remediation Research and Development Program in 1997 recommended very strongly that the vast majority of remediation efforts for the legacy of environmental impacts left by the Mount Lyell mine should be directed at treatment of the acid drainage at the lease site. Mitigation strategies for the acid drainage include:

- the diversion of clean water away from contaminated areas of the mining site;
- collection of acid drainage and extraction of a saleable copper product to generate revenue for subsequent water treatment and produce a positive environmental outcome in Macquarie Harbour;
- neutralisation of acid drainage to remove remaining copper, aluminium other metals and acidity required for downstream riverine improvement; and
- storage of metalliferous sludge in Copper Mines of Tasmania's (present operator of the Mt Lyell mine) tailings pond.

The remediation strategy is likely to be implemented in a step-wise manner. Pilot studies of the most appropriate technology to apply for treatment have been completed. An identified target is to improve water quality to such a degree that migration of native fish into the lower King River tributaries is possible. Under present conditions (0% remediation), water quality in the King River is too poor to promote fish migration or the re-establishment of an ecosystem regardless of the operation of the John Butters Power Station. If 100% of the acid drainage were remediated, power station operations probably also have little influence on water quality downstream of the Queen River, as the water quality targets would be achieved under any flow conditions; however, the occurrence of metalliferous plumes with power station turning on could still be an issue. Potentially under an intermediate scenario, where the acid drainage is partially treated, the water quality target of native fish migration into tributary streams could be achieved when the power station is operating.

The final feasibility study for the Mt Lyell Acid Drainage Remediation Program is due for completion during the second half of 2001. This will identify the most favourable option in terms of downstream improvement and economic feasibility. Based on present test work, it appears unlikely that sufficient remediation will be achieved in the short-term such that power station management is a major factor in the remediation of the King River. As remediation proceeds, the role of the power station will have to be reviewed.

5.2.2.5 Potential Changes due to Basslink

Basslink results in water levels in Lake Burbury somewhat lower than historical levels, by somewhere between one and three metres. Because the power station off-take is located so deep in the lake, this small change in lake level is unlikely to significantly alter what part of the dissolved oxygen profile is drawn into the power station. Discharge of a greater proportion of total flow during the winter period will minimise temperature differences between the King River and unregulated tributary streams. This will result in relatively less cold water being released from the power station during summer months. However, during the summer the lower King River will experience more frequent fluctuations in temperature between seasonally warm ambient water and relatively cooler power station-derived water associated with the frequent, short duration power station operations.

The seasonal shift in discharges under Basslink could see more dilution to Queen River inputs during winter months, but less dilution during summer months. Fewer long-term maintenance shutdowns as is the trend under existing conditions will help avoid the worst case scenario whereby copper-laden plumes can be pushed into Macquarie Harbour.

5.2.2.6 Mitigation Options

With regard to the copper concentrations in the lower King River, the best mitigation option of treatment at the Mount Lyell lease site is already well under assessment through the Mount Lyell Acid Drainage Remediation Program. The power station causes fluctuations in concentrations of elements such as copper, but there are no particular management issues arising from this that require mitigation. The worst case scenario of copper-laden plumes into Macquarie Harbour can be avoided by minimising maintenance shutdown periods for the John Butters Power Station, a measure which Hydro Tasmania has gradually been implementing over time and is totally unrelated to Basslink. It is anticipated that duration of maintenance shutdowns will be minimised as far as possible prior to commencement of Basslink.

Dissolved oxygen levels in the power station releases are already being adequately addressed through the use of air injection at the generator.

Addressing the issues of temperature fluctuations downstream of the power station, and aseasonal temperature releases, would need major alterations to existing arrangements. Measures required would encompass physical in-lake mixing, changes to lake level ranges, alterations to the power station intake structure, or shifting discharge patterns of the power station to minimise summer releases. All of these measures are radical and expensive for the Hydro Tasmania business, and in the absence of a remediation program in the King River they appear to be excessive.

5.2.2.7 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- the monitoring considerations of the individual researchers;
- the Basslink-related options arising from those considerations; and
- studies suggested by the researchers which, while not directly measuring Basslink effects, may contribute to better understanding of the water quality processes in Lake Burbury and the King River .

5.2.2.7.1 Researchers’ Monitoring Considerations

The monitoring considerations raised in the King River Water Quality Report (Appendix 23) include continuing the monitoring program presently in operation as part of Hydro Tasmania’s Waterway Health Monitoring Program (WHMP). This program involves regular water quality profiles in Lake Burbury and continuous recording of water quality downstream of the power station.

The report also suggested monitoring copper concentrations at the Crotty Dam site or below the tailrace during the years when Lake Burbury is not being monitored as part of the Waterway Health Monitoring Program. This would indicate changes in copper concentrations in the Lake as early as possible.

5.2.2.7.2 Basslink-related Monitoring Options

The WHMP monitoring regime should be continued before, during and after the transition to Basslink operational conditions in order to detect any unforeseen changes and track long-term water quality trends. As this monitoring already forms part of the WHMP, the work will not form part of the

Basslink Monitoring Program for the King River (see Section 5.9). However, the commitment to continue with the monitoring will be included.

5.2.2.7.3 Suggested Studies

The suggestion for monitoring copper concentrations in Lake Burbury would provide useful information about impending changes in water quality. However, copper levels will not be influenced by Basslink-related operations, so this suggestion would be more appropriately addressed under the Waterway Health Monitoring Program, and will not form part of the Basslink Monitoring Program for the King River.

5.3 Environmental Assessment of Land Impacts – Fluvial Geomorphology

5.3.1 Methods

The fluvial geomorphology of the King River was assessed by Locher and is presented in full in Appendix 24.

The method utilised was a review of the considerable existing information, supplemented by additional field data in the form of repeat survey cross-sections and delta profiles (February 2000), repeat aerial photography (February 2000 and August 2000), repeat measurement of erosion pins (January 2000 and December 2000), repeat photo monitoring (January 2000 and December 2000), and collection of suspended sediment samples (December 2000).

5.3.2 Background Information

The operation of the Mount Lyell Copper Mine has had a major influence on the geomorphology of the lower King River. The mine is located in Queenstown on the Queen River, a major tributary joining the King River just 700 m downstream of the John Butters Power Station (Map 5.1).

Mount Lyell commenced operation in 1883, first worked for gold, and from the 1890s onward worked almost continuously for copper. It has been a significant influence on the geomorphology of the Queen River downstream of the mine, and the King River downstream of the Queen River, due to its historical practices of direct discharge of mining wastes into the Queen River. Ninety-seven million tonnes of fine-grained waste sediments (tailings) are estimated to have been discharged from the mine over the period 1916 to 1994. The median grain size of the tailings gradually reduced over the history of the mine as milling methods improved, and was as fine as 11 µm (0.011 mm) just before the mine ceased the riverine discharge of tailings (Locher 1997).

In addition to tailings, an estimated 4.5 million tonnes of coarser grained smelter slag were discharged, and an estimated 10 million tonnes of eroded topsoil from the Mount Lyell lease site has also been transported down the King River. Smelter slag is much coarser than the tailings, with a median grain size of 1.5 mm. A proportion of these mine wastes accumulated in the river bed and banks of the last 8 km of the King River, and in the delta at the mouth of the King River where it meets Macquarie Harbour. Discharge of Mount Lyell mine tailings into the river system ceased permanently in December 1994 with the creation of a tailings dam.

A more recent influence on the fluvial geomorphology of the lower King River is impoundment of the King River upstream of the Queen River for the purpose of hydro-electric power generation (Map 5.2). The King River Power Scheme commenced generation in 1992, and reduced the lower King River catchment area from 809 km^2 to 250 km^2. The power scheme has significantly altered the flow regime of the lower King River by reducing both flow variability and peak flows.

Other than mine tailings discharge and flow regulation, there have been few other human influences on the King River geomorphology. Forestry operations and tourism ventures occur along the river, but have only incurred very localised to the river. The remains of two bridge crossings from the Abt Railway, which used to run alongside the river and is presently being redeveloped, are found at the Quarter Mile Bridge and Teepookana Bridge, shown in Map 5.2. Scour at bridge crossings and particularly around bridge piers is a predictable geomorphic change.

5.3.3 Present Condition

A PhD study by Locher (1997) showed that 90% of the estimated 97 million tonnes of tailings discharged by the Mount Lyell mine up until December 1994 reside in the delta at the mouth of the King River. Only 4% of these tailings are still in the bed and banks of the King River, with the remainder believed to be at the bottom of the northern part of Macquarie Harbour. Tailings are mixed with smelter slag in the bed of the King River, infilling the bed downstream of Teepookana Bridge by as much as 3.5 m within the last few kilometres of the river.

Tailings deposited on the banks are draped over the natural riverbanks, where chemical leaching and physical smothering has historically killed much of the vegetation. The King River banks appear an orange-red colour largely devoid of green vegetation, and are 6-7 m above present mean water level between Quarter Mile Bridge and Teepookana Railway Bridge, but only 1-2 m above present mean water level downstream of Teepookana.

Active adjustments of the riverbank faces of the tailings banks has been closely monitoring and documented since 1993, using erosion pins, scour chains and photo monitoring. Since the mine ceased to discharge tailings in December 1994, there have been relatively minor readjustments of the riverbank faces of tailings banks, particularly between Quarter Mile Bridge and Teepookana Bridge. Erosion pins show evidence of scour of riverbed sediments downstream of Teepookana Bridge. Seepage-induced erosion may be one of the many erosional processes active on the riverbank faces of the tailings banks, although the small range of water levels downstream of Quarter Mile Bridge in response to power station operations (<1.2 m) suggest that it is unlikely to be associated with large-scale bank collapse. Erosional processes acting on river bed and river bank sediments, which were projected by Locher (1997) to continue to cause readjustments of channel form, only affect mine waste sediments, not the natural banks or bed.

Because of the regulated flow regime greatly reducing the magnitude of floods in the lower King River, the bed and banks are not anticipated to ever return to their original geomorphology. Natural revegetation of the King River banks is occurring despite the nutrient-poor and metal-rich composition of the residual tailings material, and in time the adjacent rainforest species will stabilise the bank surfaces.

Turbid plumes occur when the power station comes on line, but are not associated with significant concentrations of suspended sediment. The water discolouration is largely due to chemical precipitation of metals from the tailings banks, and not due to erosion of the banks.

In summary, the lower King River has experienced major adjustments to its form over the last century. In the last five years since tailings discharge ceased, rates of change to riverbank morphology have slowed considerably. It is anticipated that the lower King River will continue to experience adjustments in channel form, until it eventually reaches a stable but modified geomorphology.

5.3.4 Predicted Basslink Changes

The lower King River is likely to experience some geomorphological changes due to Basslink, notably:

- An increase in scour of tailings resident in the King River bed downstream of Teepookana Bridge due to increased turning on of the power station; and
- An increased occurrence of visual plumes of suspended sediments with the power station turning on more frequently.

5.3.5 Management Issues and Mitigation Options

Scour of the river bed downstream of Teepookana Bridge is considered to be advantageous, as it helps to clear out stored mine tailings and improve access for boat traffic. Scour will not progress to the point of destabilising the channel, because the banks downstream of Teepookana are very low and flat, and the bed will armour (form a coarse top layer unable to be transported under the present flow regime) long before all of the mine waste sediments are removed.

The only potential management issue identified in Appendix 24 is a visual issue with turbid plumes arising from turning on and off of the power station. This may be an issue for tourists riding on the Abt railway. However, the historic mining impacts in contrast to the pristine wilderness are anticipated to be a feature of the tourist experience (see Section 5.7 and Appendix 28), so this may not be a significant issue.

No particular mitigation options for the anticipated Basslink changes to the lower King River geomorphology are required.

5.3.6 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- the monitoring considerations of the individual researchers; and
- the Basslink-related options arising from those considerations.

5.3.6.1 Researchers' Monitoring Considerations

The King River Fluvial Geomorphology assessment (Appendix 24) suggested:

- repeat survey cross-sections and aerial photos prior to and about five years post-Basslink;
- repeat photo monitoring and measurement of erosion pins prior to Basslink and at two yearly intervals; and
- suspended sediment sampling if turbidity becomes an issue of concern due to Basslink operations.

5.3.6.2 Basslink-related Monitoring Options

The above activities are all directly related to measuring changes which may occur following the commencement of Basslink operations. Consequently, they should form part of the King Basslink Monitoring Program (Section 5.9).

5.4 Environmental Assessment of Groundwater Impacts

There are no particular groundwater issues identified for downstream of the John Butters Power Station. Drawdown-induced erosion of the tailings banks is not anticipated to be an issue because the tailings are coarse-grained sands and drain quite freely.

5.5 Environmental Assessment of Flora and Fauna Impacts

5.5.1 Scope of this Section

This section looks at environmental information on the flora and fauna downstream of the John Butters Power Station in relation to present status and potential Basslink changes. Specific aspects of the flora and fauna which are examined are instream fauna (Section 5.5.2), and terrestrial flora and fauna (Section 5.5.3).

5.5.2 Instream Fauna

5.5.2.1 Background and Methods

The assessment of King River instream fauna was undertaken by Davies and Cook of Freshwater Systems, and is reported in full in Appendix 25.

As a consequence of the legacy of mine waste discharge and existing acid drainage issues, the King River downstream of the Queen River confluence is extremely depauperate, with no fish, few platypus and only a residual macro-invertebrate fauna. This was shown by macro-invertebrate and fish surveys described by Davies *et al* (1996) and Davies *et al* (1999), and confirmed by further toxicological investigations (Davies *et al*. 2000). The 0.7 km of river between the power station and the Queen River confluence is unaffected by mining activities, but affected by the existing power station discharge regime.

No additional surveys were conducted for this assessment, and no platypus surveys have been conducted to date in the lower King River. Substantial data was collected during surveys in 1995/96 of fish and macroinvertebrates, and these data were re-examined. The macroinvertebrate data were re-analysed using a RIVPACS predictive bioassessment model developed for the Hydro catchments by Davies *et al.* (1999), which generates an ‘O/E’ index, ranging from 0 to around 1. O/E is the ratio of the number of taxa predicted to occur at a river site in the absence of disturbance that are actually found (O = observed) there, to the number of taxa predicted (E = expected) for that site. The predictions are based on a large macroinvertebrate and environmental database derived from unimpacted reference sites sampled across the Tasmanian Hydro catchments.

An additional, detailed habitat study was conducted for the reach between the power station and the Queen River confluence, which contained both bar/rapid and pool-run habitats. This study used the same habitat simulation approach applied to the Middle Gordon River (Section 3.5.3), using aspects of the Instream Flow Incremental Methodology.

Eight transects were established across the river, a range of habitat and hydraulic data was collected and hydraulic modelling was conducted using the RHYHAB package. Modelling and habitat simulation were conducted over the range of 2 – 300 cumecs. The habitat simulation evaluated the habitat suitability and availability for all dominant fish and macro-invertebrate taxa likely to occur in the lower King catchment, based on those described from the tributaries of the lower King, the Henty and Franklin Rivers, and other streams flowing into Macquarie Harbour. Habitat availability was also assessed for platypus. WUA-Q curves were generated for 19 taxa or variables, as described in Appendix 7 on Gordon River instream fauna. Hourly data for 1998 was selected for comparative analysis, as it was hourly data from an ‘average’ rainfall year, and habitat availability was compared between natural, present and TEMSIM modelled Basslink flow regimes.

For this assessment, the lower King River was divided into three main reaches:

1. **Between the Crotty Dam and John Butters Power Station.** This is a 7.3 km long gorge which is severely dewatered. It receives limited input from small tributary streams and occasional spills. The substrate is characterised by large boulders. No biological sampling has been conducted in this reach, but it is believed to be biologically impoverished.
2. **Between John Butters Power Station and the Queen River.** This is a 0.7 km long reach which experiences highly variable discharges on an hourly to daily basis. It is inhabited by a severely impacted community of macroinvertebrates, and a fish population of brown trout in very low abundance. There are high densities of benthic algae (*Mougetia*) on the channel margins, typical of reaches downstream of variable hydro-generated flows, and indicating the elimination of macroinvertebrate grazers. There are no native fish present.
3. **Downstream of the Queen River confluence.** The ecology of this 21.1 km long reach to Macquarie Harbour is dominated by the very poor water quality sourced from the Queen River. An extremely low abundance, highly depauperate macro-invertebrate fauna survives, consisting of worms, midge larvae and scirtid beetle larvae. No fish were observed in a quantitative survey of the main river in 1996, though some native fish do occur in small tributaries near the river mouth.

5.5.2.2 Present Condition

Davies *et al* (1999) reported the O/E (observed / expected) ratios for macro-invertebrate taxa in the second and third reaches as shown in Table 5.4. Note that these ratios are with reference to unimpacted reference streams, with 0.8 – 1.2 being equivalent to reference and values between 0.8 and 0 being significantly to extremely impacted. A distinction is made between O/E scores for the thalweg (channel centre, below ‘low water mark’) and the channel margins (between the ‘high water mark’ and ‘low water mark’), and more significant alterations were detected in the channel margins due to repeated cycles of inundation and dewatering. The distinction is also made between O/E using presence-absence data (pa) and rank abundance data (rk), as described in Section 3.5.3.

Table 5.4 Present O/E ratios for King River Macroinvertebrates

	Channel centre (thalweg)		**Channel margins (between HWM and LWM)**	
	O/E pa	**O/E rk**	**O/E pa**	**O/E rk**
Power Station to Queen River	0.57 (B band)	0.38 (C band)	0.1 - 0.36 (C band)	0.06 - 0.24 (C-D band)
Downstream Queen River	**0.00 - 0.13** **(C-D BAND)**			

Environmental effects of power station operation in the lower King River (downstream of the Queen River) are intimately linked to the acid drainage (AD) issues from the Mount Lyell lease site. The abundance and diversity of instream fauna downstream of the Queen River is dependent on the dilution of AD provided by power station discharges. The worst case for the biota is when the power station is off and provides no dilution (Davies *et al.* 2000).

Davies *et al.* (1996) surveyed tributary stream fish populations in the lower King River, and found them to contain limited populations of native fish. The unusual size and age-class structures of these fish suggested that prior to construction of the King Power Scheme, the water quality conditions in the lower King River occasionally allowed intermittent recruitment of native fish juveniles into the tributary streams, probably during times of large floods. Migration appears to have ceased since dam construction, judging from the ages of these fish.

5.5.2.3 Predicted Basslink Changes

WUA-Q curves and WUA time series for the study reach between the power station and the Queen River are provided in Appendix 25. Overall, the researchers believe that there is little change in the habitat availability for most of the study taxa when the Basslink WUA time series are compared with those for existing conditions.

Under Basslink there will be a reduced length of low flow events, an increased occurrence of high flow events, and greater frequency of higher flows in winter. Any benefits from these will however, be off-set by the continuation of high variability in flows at short time steps (1-24 hours), the ongoing lack of flow peaks greater than 90 cumecs, and by decreases in the incidence of higher flows during the summer period.

Overall, the researchers anticipate that the flow regime under Basslink will be neutral to marginally beneficial to biological recovery downstream of the John Butters Power Station, compared to existing operations. They conclude that Basslink will not change the biological suitability of the lower King River under existing water quality conditions.

If Queen River water quality is significantly improved, the potential for re-establishment of macroinvertebrates and fish within the King River is marginally enhanced during winter under Basslink, although still impacted by power station off-periods during summer.

The potential for native fish migration will remain unchanged due to Basslink, as the magnitude of peak flows out of the power station will not change.

The researchers summarise that under Basslink there will be:

- no substantial change in the abundance and diversity of macroinvertebrates in the river between the John Butters Power Station and the Queen River junction;
- no substantial change in the potential for ecological recovery downstream of the Queen River junction following remediation of AD problems at Mount Lyell; and
- no implications for the fauna of the lower King River if AD pollution is not significantly reduced.

5.5.2.4 Mitigation

Because Basslink is not predicted to substantially alter the existing biological condition of the lower King River, either above or below the Queen River junction, no mitigation options are recommended in relation to the Basslink changes.

5.5.2.5 Monitoring Options

The predominant aim of the Basslink monitoring program is to determine the effects of Basslink operations and those of any mitigation measures which may be established. The following sections summarise:

- ➢ the monitoring considerations of the individual researchers;
- ➢ the Basslink-related options arising from those considerations; and
- ➢ studies suggested by the researchers which, while not directly measuring Basslink effects, may contribute to better understanding of the instream biota of the waterways downstream of the John Butters Power Station.

5.5.2.5.1 Researchers' Monitoring Considerations

The King In-stream Biota Assessment (Appendix 25) suggested monitoring for macroinvertebrates, fish and platypus.

The suggested macroinvertebrate monitoring activities included twice-yearly sampling at the existing King River site upstream of the Queen River junction.

The researchers suggested the monitoring of native fish abundance and diversity in the lower King catchment, as well as information about those flow and water quality conditions under which recruitment occurs from Macquarie Harbour into the catchment.

The assessment suggested that the issues of monitoring platypus populations and algae in the King River were of a lower priority than fish or macroinvertebrate monitoring.

5.5.2.5.2 Basslink-related Monitoring Options

Twice-yearly (October and April) macroinvertebrate sampling at the existing King River site upstream of the Queen River junction should be carried out three years pre-Basslink and three years post-Basslink. Data from reference sites, such as the Franklin and Jane Rivers, collected as part of the Gordon Basslink Monitoring Program, should be used in comparative analyses with the King River data. A sampling and analysis methodology was given in the Assessment (Appendix 25).

The researchers suggested the monitoring of native fish abundance and diversity in the lower King catchment should be carried out twice-annually (December and April) for three years pre- and three years post-Basslink.

The following sites should be sampled:

- King River between the power station and the Queen River junction;
- reference streams – Botanical and Connellys Point Creeks, Tully River.

Both fish and macroinvertebrate monitoring will be included in the King Basslink Monitoring Program (Section 5.9).

5.5.2.5.3 Suggested Studies

The researchers also suggested monitoring fish movement into tributaries of the lower King River, including Four Mile, Kingfisher, Virginia, and Lower Landing Creeks. It is unlikely that any Basslink-related operations will affect the ability of fish to migrate up the river in any way differently from those presently in place. The principal barrier to fish migration in the King River is the poor water quality. Therefore, the King Basslink Monitoring Program will not include sampling of the tributary streams.

The likelihood of Basslink operations impacting on platypus populations in the King River is very low. Should the fish or macroinvertebrate monitoring activities indicate that there is increasing or unusual platypus activity in the King River, the topic should be included in the issues for consideration in the technical studies of the King Water Management Review.

5.5.3 Terrestrial Flora and Fauna

No dedicated study was conducted on the terrestrial flora or fauna of the King River downstream of the John Butters Power Station. The main issue would be in relation to revegetation efforts on the exposed tailings banks in the lower King River.

Over 40 demonstration plots were established in 1995 and 1996 as part of the Mount Lyell Remediation Research and Demonstration Program, to assist future planning decisions associated with rehabilitation and management of the King River delta and riverbanks. The aim of the demonstration plots was to trial a range of rehabilitation treatments (Photo 5.1). Monitoring of the trial plots has been continued since their establishment. Recommendations from a February 2000 review (Duckett 2000) include the following:

- Rehabilitation efforts should be concentrated on stable sites upstream of Teepookana Bridge.

- General fertiliser broadcasting encourages the establishment of moss, and if applied to the vegetated perimeter and banks, will encourage natural colonisation. Moss establishment and consequent tailings stabilisation particularly from the effects of wind in turn encourages colonisation and a transition towards rainforest species (see Photo 5.2 and Photo 5.3).

- Rehabilitation should not be implemented on sites prone to flooding, namely those downstream of Teepookana Bridge.

Basslink is not likely to have any implications for the stability of the King River tailings banks, and so there are no likely issues arising from Basslink for the encouragement of vegetation on the King River banks.

Photo 5.1 Aerial view of a revegetation trial plot (Bank M) in the King River, established in 1995-96.

Photo 5.2 Aerial view illustrating the natural encroachment of mosses, restio and seedlings across a King River tailings bank upstream of Teepookana Bridge.

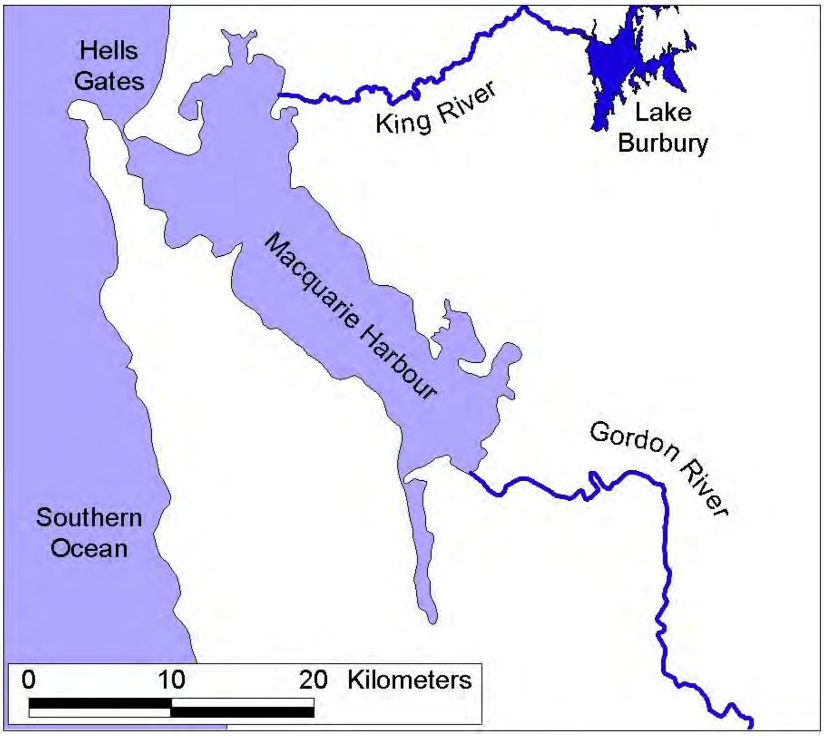
Photo 5.3 Aerial view of tailings Bank R in the foreground and Bank Q in the background, with the original Quarter Mile Bridge in between, illustrating the natural encroachment of vegetation.

5.6 Environmental Assessment of Estuarine Impacts – Macquarie Harbour

5.6.1 Introduction and Methods

The main estuarine environmental issue to be assessed in relation to Basslink is the potential effect of Basslink changes to the John Butters and Gordon power stations on water quality in Macquarie Harbour. This issue was examined by Koehnken and is reported on in full in Appendix 26. Public and commercial usage of Macquarie Harbour, and potential effects of Basslink changes, have been considered separately in Appendix 28, and are summarised in this report in the following section (Section 5.7).

Macquarie Harbour is an enclosed embayment with very restricted water exchange with the Southern Ocean, as shown on Map 5.3. The harbour is approximately 33 km long and 9 km wide, and is generally narrow and shallow, with the exception of a deep central depression 5-10 km south of the King River mouth where depths can exceed 50 m. The major freshwater inputs and influence on circulation patterns are from the King and Gordon Rivers, both regulated and identified as being subject to operational changes due to Basslink. The Gordon River provides about five times the contribution of the King on a yearly basis (mean annual flows for Gordon = 265 m^3/s and King = 55 m^3/s), with flow from about 25% of the Gordon and 60% of the King catchments controlled by flow regulation.



Map 5.3 Macquarie Harbour, showing the Gordon and King Rivers and Hells Gates, the outlet into open ocean.

A considerable number of studies of Macquarie Harbour have been undertaken over the past decade, most notable being the investigations into water, sediment and biological condition by the Mount Lyell Remediation Research and Demonstration Program (MLRRDP). An ongoing monitoring program by DPIWE has provided extensive information on water quality over an eight year period, and two numerical models of the hydrodynamics of Macquarie Harbour have been developed.

Description of the present condition of the harbour draws on this available information. Predictions of alterations under Basslink were made by using runs of one of the existing numerical models, the Princeton Ocean Model parameterised by Terry (1998) for Macquarie Harbour, with a number of Basslink flow scenarios.

5.6.2 Description of Present Condition

Figure 5.9 and Figure 5.10 illustrate the present circulation patterns in the harbour:

- The flood tide pattern (Figure 5.9) shows the incoming surface currents from the Southern Ocean, and two surface gyres of the King freshwater in the northern harbour and the Gordon freshwater in the central harbour. Sub-surface flow of King River water towards the southern end of the harbour can be seen to occur.
- The ebb tide pattern (Figure 5.10) shows the King freshwater forming a strong surface current exiting the harbour, but still providing a sub-surface flow to the southern end of the harbour. The Gordon water forms a strong northerly flow along the south-western side of the harbour with some of this water exiting the harbour, and the remainder forming the same central gyre seen under the flood tide, or flowing below the surface to the north-eastern part of the harbour.

Generally the harbour has a surface wind-mixed freshwater layer overlying an ocean-derived saline layer. The water quality of the harbour is controlled by the complex interactions of the highly contaminated King River water, and the pristine seawater and high quality Gordon River water. Copper, aluminium and other metals all enter the harbour from the King and are dispersed by wind mixing and currents. Virtually all water samples from the harbour over the eight years of DPIWE monitoring exceed the ANZECC (1992) Water Quality Guideline for the protection of aquatic ecosystems of 5 μg/L of total copper. Harbour currents shown in Figure 5.9 and Figure 5.10 result in the transport of copper southward into the eastern half of the harbour, and export of copper-rich waters on outgoing tides. The highest concentrations of metals are present in the surface of the northern harbour when King River water persists as a plume, i.e. high discharge from the King and low or no wind which minimises mixing with saline ocean-derived water.

‘Worst case’ flow scenarios for water quality in the harbour are:

- very low flows in the Gordon River, which can weaken the strong surface current along the western harbour allowing dispersion of weakly diluted King River water into the western harbour; or
- high King River flows, which can increase the pollutant load to the harbour and create surface plumes.

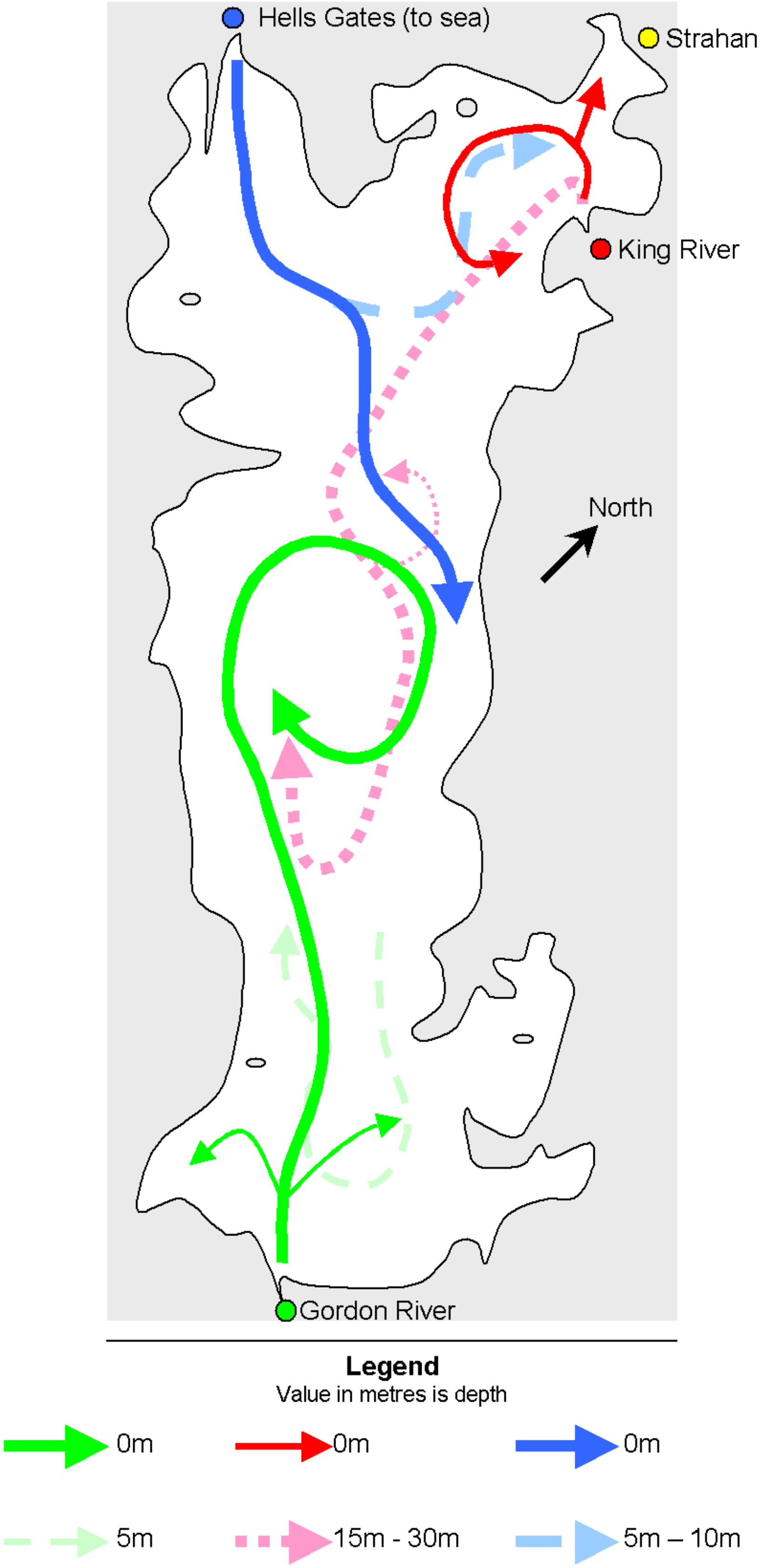


Figure 5.9 Flood tide in Macquarie Harbour, arrow width indicates flow rate and arrow colour indicates water source and depth

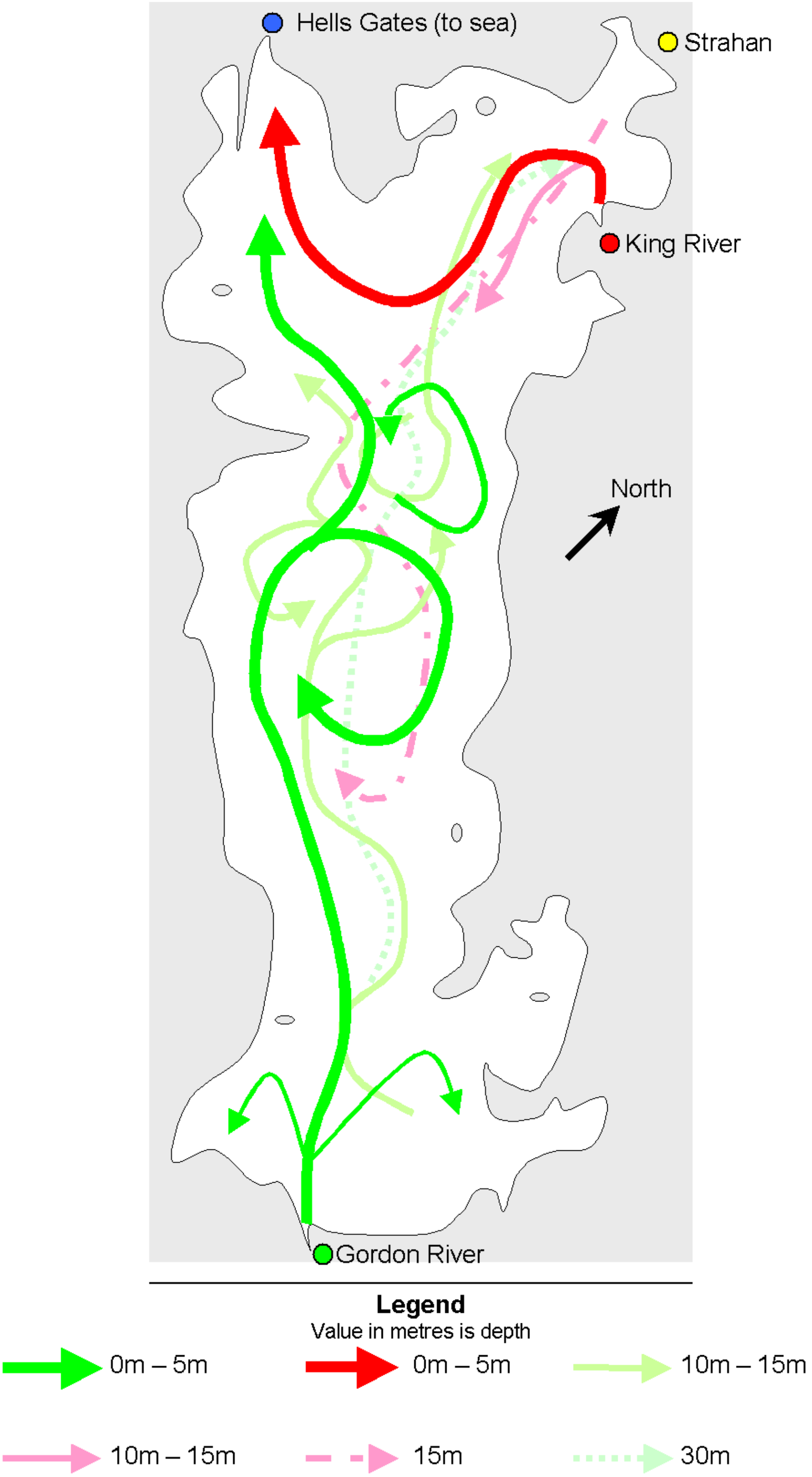


Figure 5.10 Ebb tide in Macquarie Harbour, arrow width indicates flow rate and arrow colour indicates water source and depth

Despite the high copper levels, the toxicity of the copper is much lower than would be expected from the literature. The reason for this is not completely understood, but is believed to involved complex interactions amongst the copper, dissolved organic matter and the organisms.

Benthic invertebrates, fish and phytoplankton in the harbour have all been found to be depauperate and negatively impacted by mining inputs. Harbour sediments play an important role in the uptake and release of metals from the water column, and the presence of vast deposits of highly contaminated sediments in the harbour will remain an impediment to recovery of benthic invertebrate communities even if harbour water quality is improved.

5.6.3 Potential Basslink Changes

Hydrological changes to flows in the King and Gordon River due to Basslink are summarised in Appendix 26 as producing the following effects on Macquarie Harbour:

- Increase median winter inflows from both the King and Gordon catchments, with an associated decrease in median summer flows compared to present (although total discharge on a seasonal basis will be unaltered);
- Produce a pulsed input of high flow from the Gordon during the week, with little or no power station derived flow during weekends; and
- Introduce higher concentrations of metals from the King during summer due to reduced dilution, although long duration events with low flow / high metals will be reduced.

The net effect of these changes is a shift in flow patterns to one where there is greater correlation between King and Gordon inputs to the harbour. This correlation is more typical of natural conditions, as rainfall patterns appear to affect the two catchments at similar times. Under Basslink, situations where the King River flow is high compared to Gordon flow are reduced.

The model runs using the Princeton Ocean Model identified no significant changes to Macquarie Harbour circulation or pollution risk under Basslink operating patterns for the John Butters and Gordon power stations.

Interestingly, the modelling showed that both the Present and Basslink scenarios result in lower pollution risk in the harbour compared to natural conditions, due to the greater influx of freshwater from the Gordon River during the summer. The development of the aquaculture industry in the harbour, discussed further in Section 5.7.5.4, relies on the higher than natural summer discharges out of the Gordon River for the maintenance of fresh surface conditions.

5.6.4 Management Issues / Mitigation Options

There are no mitigation options required for Macquarie Harbour in relation to predicted Basslink changes. There may be, however, management issues arising for the harbour if mitigation options are put in place to address other issues. The main concern would be if the Gordon Power Station was shut down for extended periods, even as little as one week, during summer months. This could lead to a more saline surface water layer which is a risk for aquaculture, and permit the migration of polluted King River water into the aquaculture leases.

No specific Basslink monitoring is recommended in Appendix 26.

5.7 Environmental Assessment of Socio-Economic Impacts

5.7.1 Scope of this Section

This section examines socio-economic issues downstream of the John Butters Power Station in relation to present status and potential Basslink changes. Specific aspects examined are the cultural heritage (Section 5.7.2), visual amenity (Section 5.7.3), public use and public safety (Section 5.7.4), and industries affected and economic impacts (Section 5.7.5).

5.7.2 Cultural Heritage

The assessment of King River cultural heritage involved both Aboriginal cultural heritage and European cultural heritage, and is reported on in full in Appendix 27.

The review of Aboriginal heritage was a desktop survey, which included a search of the Tasmanian Aboriginal Site Index (TASI) and a review of existing reports on Aboriginal heritage surveys and background reports.

There are a number of previous studies which have been carried out in the general King River (pre-dam) catchment and region, but very little available on the actual study reach. The general King River catchment area and region contain a number of Aboriginal heritage values of medium to high significance.

The only previous study which has looked particularly at the reach between the John Butters Power Station and Macquarie Harbour are surveys for the Restoration of the Abt Railway undertaken by Sinclair Knight Merz (SKM) in 1999. The SKM survey found no sites or values significant to Aboriginal heritage along the banks and surrounding areas of the lower King River (downstream of the power station). Visibility in these surveys was often severely restricted due to the thick humic layer of the surrounding forests, but there is also considerable human disturbance (forest clearings, cuttings and tracks) which led the SKM investigators to conclude that visibility was sufficient to reach their conclusions. The SKM investigators concluded that the high degree of European activity, primarily from the construction and operation of the Abt railway and associated stations, would have disrupted and disturbed any sites of Aboriginal heritage value along the King River.

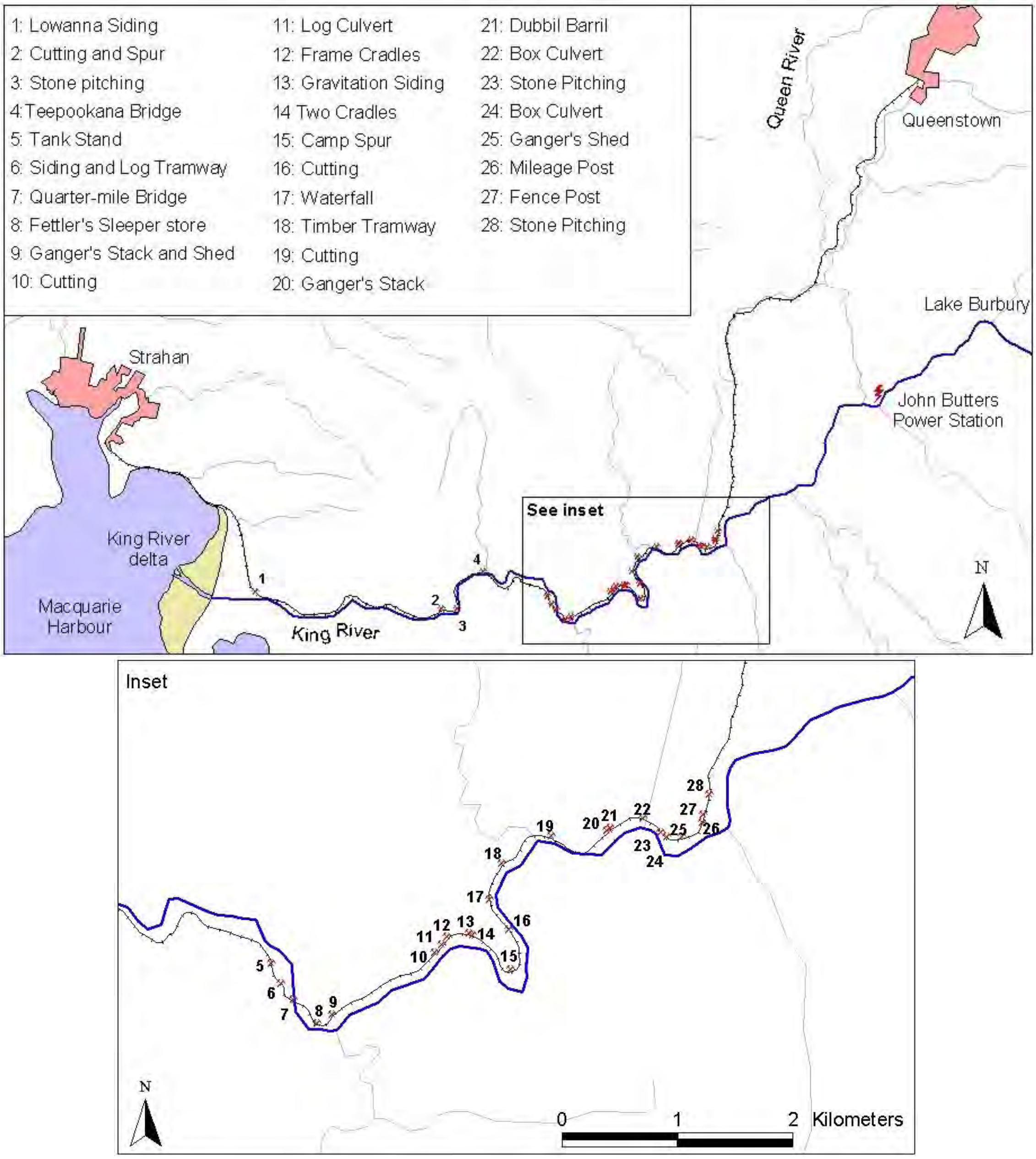
The most significant cultural heritage value along the King River is the construction and operation of the Abt railway and associated stations. The Abt railway was built between 1894-1899, and operated until 1963. It linked the copper mines at Queenstown with initially the port at Teepookana on the King River, and later to Regatta Point wharf on Macquarie Harbour.

There have been a number of cultural heritage studies in the region of the King River, the most relevant again being the SKM 1999 survey for the Restoration of the Abt Railway. This survey identified 84 sites of cultural heritage value associated with the railway system, including sidings, cottages, stations, bridges, cuttings and spur cliff remnants, stone pitchings, trusses and a ballast quarry (see Map 5.4). The majority of these sites are located a distance away from the riverbank. There are however some sites directly on the river and subjected to water level fluctuations due to power station operations, specifically:

- **Cutting and spur remnant** at Site 2 – demonstrate engineering design standards on the railway. Technically important and should be protected.
- **Stone pitching and backing** – Lowanna siding to Teepookana (Site 3). A section of stone pitched embankment locally known as the ‘Stone Wall’, approximately 110m long, falling to the King River on an ‘outside’ bend. Also associated with a section of sand that may conceal pitching beneath. Formation is now a roadway. Technically important, disturbance should be avoided.

- **Teepookana Iron Bridge** rail bridge and wharf – Site 4. The base of the structure is submerged and there is a concrete abutment at the western approach to the King River. Historic, aesthetic, technical and social importance, disturbance should be avoided.
- **Quarter Mile Bridge** – Site 7, over King River at Hells Gates. Timber sheeting and walings to secure the sheeting into the riverbank, protective stone pitching on riverbank, truss and plate girders lying against the riverbanks. Flooding has devastated the site. Historic, technical and social importance, disturbance should be avoided.

All of these sites are very robust structures that have survived 100 years of major floods, other than Quarter Mile Bridge which collapsed due to flooding. These structures are not able to be altered due to water level and flow fluctuations arising from power station operations, either under present or predicted Basslink regimes.



Map 5.4 King River cultural heritage sites.

From the geomorphology report (Appendix 24), it is known that the mine tailings often overlie the original river banks, and that the river has not become narrower due to tailings deposits. Therefore, gradual erosion of the mine tailings over time could expose original banks which may expose cultural heritage relicts such as old glass bottles. No major structural relicts are anticipated to lie beneath the tailings.

Power station operations could potentially compound management issues created by direct disturbance to these sites from other activities (e.g. jet boat, Abt railway construction), so these disturbances should be avoided.

This appendix concludes that there are no cultural heritage management issues on the King River in relation to Basslink, and so no mitigation measures are required. Monitoring recommendations are to periodically inspect and photograph the four sites known to be on the King River itself. Further monitoring is not expected to be required unless erosion is observed to be impacting on any cultural heritage sites.

5.7.3 Visual Amenity

The visual impact of the residual effects of mine waste discharge in the lower King River is a dramatic and unique feature, particularly as it is surrounded by pristine and extremely dense forests. The mine wastes have resulted in massive mine sediment storages draped over the natural river banks, killing all vegetation on the banks. These deposits are visually prominent due to their bright orange colour created by oxidisation of the sulphide minerals contained in the tailings.

Views of the King River below the John Butters Power Station can be obtained from the air, by car, by train, by boat, by foot or by mountain bike. These views are considered in detail in the following sections.

5.7.3.1 Views from the Air

Scenic flights out of Strahan are a popular tourist activity, so this view is most likely to be obtained by tourists. The passenger will see very clearly the tailings banks in the last eight kilometres of the King River (Photo 5.4) and the very large delta at the river mouth (Photo 5.5). Depending on power station operations and influencing factors in the Queen River catchment, such as the level of contaminated runoff from the Mt Lyell mine, the passenger may see a dramatic contrast in water colour at the confluence of the Queen and King Rivers (Photo 5.6) and/or a plume of discoloured water exiting from the King River delta to Macquarie Harbour (Photo 5.7).

Photo 5.4 Lower King River

Photo 5.5 King Delta in Macquarie Harbour

Photo 5.6 Confluence of the King (upper left) and Queen (lower left) Rivers.

Photo 5.7 Tailings plume in Macquarie Harbour

5.7.3.2 Views from a Car

The John Butters Power Station can easily be accessed by car from Queenstown, with the road crossing the King River just a few hundred metres downstream of the power station. This view shows a broad cross-section with a coarse cobble bed exposed or inundated to varying degrees depending on the operations of the power station (Photo 5.8). The channel in this reach is quite stable. This view is upstream of the Queen River confluence, and inflows to the King River from the Queen River are not visible from this vantage point.

Photo 5.8 Cobble bars on the King River a short distance below the Power Station.

Until February 2001, cars have been able to drive from Strahan to the King River delta, and along the most downstream five kilometres of the King River to the Teepookana Railway Bridge. This access to the King River is no longer an option, as the road along the King River downstream of Teepookana is being redeveloped for the Abt train route. Access by car will continue to be possible to Lowanna, which is only a few hundred metres upstream of the King River delta. In this section of the river, the rust-stained tailings deposits are flat-lying, with abundant dead tree trunks protruding from the bank surfaces. There is little new vegetation along the banks. Therefore car access is limited to downstream of the power station and immediately upstream of the mouth.

5.7.3.3 Views from the Abt Railway Route

The Abt railway route meets the King River downstream of Sailor Jack Creek, and follows the King River along the right bank to the Quarter Mile Bridge. The train route crosses the King River via the Quarter Mile Bridge, then follows the left bank to Teepookana Bridge. The train route then re-crosses the King River at the Teepookana Bridge, and follows the river downstream for five kilometres to the river mouth. Views along this route are considered in detail in this section, as redevelopment of the Abt railway is anticipated to attract a considerable number of viewers to the lower King River.

Between Sailor Jack Creek and Quarter Mile Bridge, the passengers will see little evidence of mining impacts as there are no significant tailings storages in this reach (Photo 5.9). The river in this reach is narrow, with densely vegetated adjacent banks rising up to very steep valley sides. The passengers will see varying degrees of exposure or inundation of the cobble bed depending on the discharges coming out of the power station. Generally, the water colour in the King River is dark tannin-brown, due to the dominance of clean water in the catchment, whether the power station is operating or not. However, under certain conditions, such as the initial start-up of the power station or rise in water level due to rainfall which flushes pollution out of the chemically active banks, or during large rain events when the power station is off and the Queen is contributing a high proportion of the flow, the water in the King River can turn a range of colours, varying from mustard yellow to orange-oxide red. Typically these colour changes are short-lived, lasting a few hours at the most, before the more usual tannin-brown colour returns.

Photo 5.9 King River between Sailor Jack Creek and Quarter Mile Bridge.

The train route approaches the Quarter Mile Bridge by crossing over several hundred metres of 'Bank R' as identified in the Geomorphology assessment. Bank R is the furthest upstream and largest tailings bank storage in the King River. In crossing the surface of Bank R, the passengers will see devegetated, coarse-grained orange-coloured sands with the occasional dead tree trunk (Photo 5.10), and wind-blown features such as dunes and scour holes.

Photo 5.10 Windblown dunes along banks of King River.

In crossing the Quarter Mile Bridge, the viewer is afforded downstream riverbank views of Bank R and the major tailings bank located on the opposite bank, which is quite similar in appearance (Photo 5.11). Cobble bars in the channel bed may be exposed at low flows with the power station off, and the viewer may observe that the bars show significant chemical cementation (Photo 5.12). Precipitation of iron hydroxides, and the occurrence of a bright green algae associated with acid drainage, may be observed at low flows in very shallow waters at the channel margins (Photo 5.13). If the train were to cross soon after a water level rise at this location due to the power station turning on or a large rain event, passengers may notice a distinct loss of clarity and discolouration of the water to a mustard yellow to olive-brown colour as described previously.

Photo 5.11 Downstream riverbank views of Bank R

Photo 5.12 Cemented cobble banks

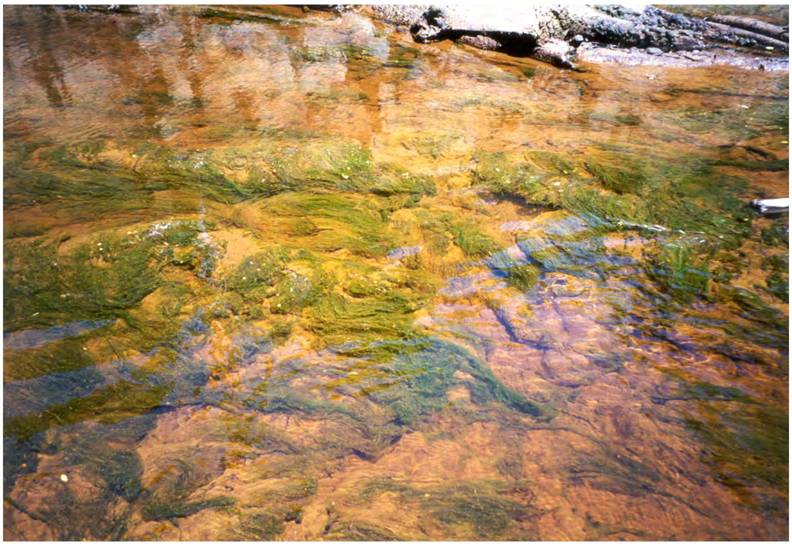


Photo 5.13 Algae growing in channel margins

Once across the Quarter Mile Bridge, passengers will see only dense rainforest until 500m upstream of Teepookana Bridge and in crossing this bridge. Recent erosion and bank retreat are evident along the right bank in the 500 m upstream of Teepookana Bridge, which is very possibly being activated by the jet boat operations. When crossing Teepookana Bridge, passengers will get a very clear look at a bank immediately upstream of the Teepookana Bridge on the right hand side, on the upstream side of Virginia Creek (Photo 5.14). The bank surface here is the site of a very successful revegetation trial; the river face of this bank, however, has actively retreated over the past five years and can be linked to jet boat activities with a fair degree of confidence.

Photo 5.14 King River at Virginia Creek confluence

The 1½ kilometres downstream of Teepookana Bridge are relatively narrow amidst a steep-sided valley, with no significant tailings storages or evidence of mine impacts.

The train passengers then reach the most downstream 3½ kilometres of the lower King River, and travel along the right hand side of the river immediately adjacent to a series of very broad, flat tailings banks, totally devoid of vegetation other than occasional clumps of restio (Photo 5.15). The river channel itself is very broad with a bottom predominantly composed of tailings sand and slag.

Photo 5.15 Tailings banks along lower King River

The passengers may obtain a glimpse of the King River delta, which is a vast 250 hectare expanse of flat unvegetated sand (Photo 5.5).

5.7.3.4 Views from a Boat

The very popular Gordon River cruises out of Strahan provide a view of the King River delta. Passengers see the vast expanse of orange sand, and may notice discoloured water emanating out of the delta under certain conditions discussed in Section 5.7.3.1. This view would be the same for recreational and professional fishers pass through this part of Macquarie Harbour.

Jet boat tours of the lower King River have been operating for approximately five years. The boat departs from Strahan, and cruises through the main channel in the delta up to Teepookana Bridge, and generally only a few hundred metres further upstream. When access further upstream is desirable, the operator has communicated with Hydro Tasmania and co-ordinated river travel with periods of higher flow. The passengers see views similar to those described for the train passengers, but from a mid-channel perspective which permits a detailed view of the riverbank faces, and a look at the channel bed given sufficient water clarity and relatively low water levels. The riverbank faces downstream of Teepookana are only 1-2 metres high, and appear very gnarly and crusted. The passenger clearly sees the active erosion of the bank faces in the few hundred metres of the river upstream of Teepookana Bridge (on the right hand side when facing downstream). If higher flows permit travel further upstream, the passengers will see significant tailings bank storages with riverbank faces 6-7 m high, and the bank faces in varying states of smooth sand slope, or crusted and gnarly but stable, or occasional slips and collapse.

5.7.3.5 Views from on Foot or Mountain Bike

Views can be obtained anywhere along the King River by following the Abt railway route or other small tracks. These routes are fairly difficult to follow, and the numbers of viewers by these means would be very low. Views obtained by these means would not be any different to those described in the above sections.

5.7.3.6 Changes to Present Views with Time

Under existing conditions, natural revegetation is gradually reducing the spatial extent of the views of tailings bank surfaces. Where assisted, revegetation is covering exposed tailings very quickly.

5.7.3.7 Potential Visual Changes due to Basslink

Basslink operation of the John Butters Power Station would not change the nature of the views described in the above sections.

There is some potential for the discolouration of water occurring when the power station turns on to occur on a more frequent basis under Basslink, with the projected increase in ‘on-off’ operation of the power station.

There may be minor adjustments to limited sections of riverbank faces particularly between Quarter Mile Bridge and Teepookana Bridge under a Basslink regime. These would probably not be visible to the Abt railway or jet boat passengers, and most likely only evident to scientific researchers conducting photo monitoring.

5.7.4 Public Use and Public Safety

Appendix 28 by Koehnken examined public uses of the King River and Macquarie Harbour. Public use of the lower King River is most likely to be by tourists either on the Abt railway or in the jet boat, with infrequent usage by venturers on foot or mountain bike, and scientific researchers. Basslink implications for the Abt Railway and the jet boat are considered in Section 5.7.5 which addresses industries affected. There are no identified issues for tourists or scientific researchers arising from the Basslink changes downstream of the John Butters Power Station.

There are no particular public safety issues in the lower King River related to power station operations, as anyone actually in or on the river would most likely be in the jet boat which has its own safety precautions.

There are public safety issues immediately downstream of the tailrace, which can be accessed by car and then a fairly easy walk down to the water's edge. Signs warn the public that water levels may suddenly change (Photo 5.16), and this precaution will be equally effective as a public safety measure with the increased on-off operation of the power station under Basslink.

Photo 5.16 Public Warning Sign on the King River immediately downstream of John Butters Power Station

5.7.5 Industries Affected and Economic Impacts

Industries operating in or adjacent to the King River and Macquarie Harbour that are potentially affected by Basslink are identified and discussed by Koehnken in Appendix 28 (Downstream John Butters Public Use Assessment). These industries include the Abt railway, the jet boat tours, Forestry Tasmania operations and aquaculture. The method of assessment was by stakeholder consultation, mostly in person during January 2001. The assessment shows that there are no issues for these industries and the west coast economy arising from Basslink. The four industries are considered here in turn.

5.7.5.1 The Abt Railway

The Abt Railway line ran alongside the Queen and King Rivers for almost seven decades from the late 1890s to 1963, delivering copper (and pyrite) ore from the Mount Lyell mine to ocean-going boats originally at Teepookana on the King River, and later to Regatta Point on Macquarie Harbour. The redevelopment of the Abt Railway is a major tourism project that is anticipated to greatly increase the number of visitors to the King River. The present flow regime in which flooding is greatly reduced due to impoundment of Lake Burbury is of benefit to the railway redevelopment, as the original Abt Railway incurred high maintenance costs associated with flooding events.

The anticipated flow changes with Basslink are not expected to affect the redevelopment of the Abt Railway. There are no implications for the engineering works. There may be aesthetic concerns for passengers on the railway, in relation to viewing the river at times with little to no flow due to power station shutdowns, and viewing turbid plumes associated with the power station turning on. These events may occur on a more regular basis with Basslink. However, in discussions by the Appendix 28 researcher with Abt Railway representatives, the whole topic of historic mining pollution is recognised as unavoidable, and is anticipated to be a feature of the tourist experience.

5.7.5.2 Jet Boat Tours

The King River jet boat tours depart from Strahan and travel up the King River. Under existing conditions, jet boat access to the King River can be hindered during dry periods accompanied by strong northerly winds, as dust clouds are mobilised from the King River delta and are too uncomfortable for tourists. Access to 1 km upstream of Teepookana Bridge can be achieved under low flow conditions (power station off) and is the typical extent of the tours. Access further upstream can be arranged, and requires the operator to communicate with Hydro Tasmania so that river travel times can be co-ordinated with periods of anticipated higher flow.

The anticipated Basslink changes to the King River hydrology are expected to have little impact on the present operation of the jet boat in the King River. The operator saw some potential opportunities for the business under a Basslink flow regime, particularly the possibility of conducting longer tours further upstream on the King River during periods of full capacity discharge. More consistent and higher John Butters discharges during the winter months under a Basslink regime would favour this possibility, as longer tours would be most feasible during the non-summer months when lower visitor numbers were experienced.

5.7.5.3 Forestry Tasmania Operations

Land zoned as State Forest in the downstream parts of the King River catchment is managed by Forestry Tasmania. During the 1990s, Forestry Tasmania has conducted two significant activities in the vicinity of the King River:

1. Maintenance and upgrading of a road from Strahan to Teepookana along the abandoned Abt Railway route, and establishment of tourism facilities including interpretation signage, viewing platforms and short walks; and

2. Salvaging of fallen Huon pines on the Teepookana Plateau east of Teepookana Bridge, and utilisation of a barge immediately downstream of the Teepookana Bridge to transport the timber from the Plateau across the river to the Strahan road. Utilisation of the barge has required periodic dredging of mine tailings particularly when the Mount Lyell mine was still discharging. Most recently, the iron bridge at Teepookana has been upgraded, resulting in removal of the barge and utilisation of the bridge by Forestry Tasmania.

With the redevelopment of the Abt Railway, vehicular access along the Strahan Road to Teepookana Bridge will no longer be possible. Future access arrangements for Forestry Tasmania to the Teepookana Plateau are still under consideration, but Forestry Tasmania has advised that it is unlikely to be dependent on river barges. Forestry Tasmania does not anticipate any issues for their operations with the projected Basslink changes to the King River hydrology.

5.7.5.4 Aquaculture

Production of Ocean (rainbow) Trout and Atlantic Salmon is a major industry in Macquarie Harbour. The largest threat to this industry is the poor water quality introduced to Macquarie Harbour via the King River (see Section 5.2.2). Farming in the harbour is prohibited by the State Government in the northeastern harbour near the mouth of the King River, and is concentrated in the central and western parts of the harbour which is most influenced by Gordon River and ocean-derived water. The aquaculture industry benefits greatly by the existing flow regime in the Gordon River, which maintains a fresh surface layer year round in the central and western parts of the harbour (see Section 5.6).

Modelling work assessing Basslink changes to Macquarie Harbour (Section 5.6) showed no significant changes to either Macquarie Harbour circulation patterns or pollution risk under Basslink operating regimes for the John Butters and Gordon power stations. As a consequence, Basslink poses no issues for the aquaculture industry.

5.8 Downstream John Butters Environmental Issues and Mitigation Options

5.8.1 Approach

For each study undertaken downstream of the John Butters Power Station, the following section (5.8.2) very briefly summarises the present condition and the Basslink trends. Changes compared to the pre-dam condition, which were considered for the Gordon and Poatina studies, are not specifically stated here because they include a complex history of mining impacts. Where there are interactions between mine-related impacts and power station operations, they are identified under present condition.

Section 5.8.3 summarises which of the studies predict further degradation due to Basslink, and then assesses the need for mitigation options.

5.8.2 Conclusions from the Individual Studies Downstream John Butters

5.8.2.1 King River Hydrology

- *Present Condition* - Curtailing of major floods, more restricted flow range, less variability in flows. Regular on-off and fluctuating flow operation of the power station with peak discharges in autumn and spring.
- *Basslink Trends* – Slight increase on on-off operation, and slight seasonal shift based on median discharges, with peak discharges in winter.

5.8.2.2 King River Water Quality

- *Present Condition* – Downstream of tailrace but upstream of Queen River experiences reduced temperatures in summer compared to unregulated rivers. Downstream of Queen River experiences controlled dilution of acid drainage (AD) delivered from the Queen River due to regulated flows. On-off power station operation causes fluctuations in degree of dilution and cold water inputs. Discoloured, high metal-bearing plumes associated with increasing water level, whether from power station or storm events.
- *Basslink Trends* – Slight increase in the fluctuations affecting dilution and cold water inputs. Potential increase in frequency of high concentration metal plumes due to more frequent operation of the power station.

5.8.2.3 King River Fluvial Geomorphology

- *Present Condition* – Ongoing scour of bed sediments downstream of Quarter Mile Bridge as the vast storages of mine waste sediments are gradually transported downstream. Ongoing adjustments to the King River bank profiles by a range of erosion mechanisms as the river continues to adjust to the cessation of tailings discharge. Downstream of the Queen River, small plumes in suspended sediments are associated with turning on of the power station, although these are primarily chemical in origin and do not indicate significant erosion.
- *Basslink Trends* – Possible increase in removal rate of tailings in river bed due to increased scour, and increased occurrence of small turbid plumes, both due to power station turning on more often.

5.8.2.4 King River Riparian Vegetation

- *Present Condition* – Upstream of Teepookana Bridge, gradual unassisted revegetation of the exposed tailings banks, and rapid assisted revegetation where trials have been conducted. Downstream of Teepookana Bridge, revegetation trials have been unsuccessful due to episodic inundation and poor quality soil water.
- *Basslink Trends* – No implications for riparian vegetation.

5.8.2.5 King River Instream Fauna

- *Present Condition* – Macroinvertebrate and fish communities downstream tailrace but upstream of Queen River are severely impacted by power station impact on flow regime, and are extremely impacted downstream of Queen River due to mine-associated pollution.
- *Basslink Trends* – No significant implications.

5.8.2.6 King River Cultural Heritage

- *Present Condition* – Four sites of historical heritage significance related to Abt Railway operations are exposed to water level changes in the King River. These structures, however, have withstood major floods for a century and are not subject to change due to power station operations.
- *Basslink Trends* – No significant implications.

5.8.2.7 Macquarie Harbour Water Quality

- *Present Condition* – Hydrodynamics of harbour greatly controlled by freshwater inflows from King and Gordon rivers. Strong summer Gordon flows provided by the power station protect the aquaculture industry from incursions of polluted King River water and provide a fresh surface lens.
- *Basslink Trends* –King and Gordon freshwater inflows are more coincidental (similar to natural proportions between the two rivers), which lessens the probabilities of metal-laden King River plumes extending far into the harbour. Modelling work assessing Basslink changes to Macquarie Harbour showed no significant changes to either Macquarie Harbour circulation patterns or pollution risk under Basslink operating regimes for the John Butters and Gordon power stations. Strong summer Gordon River flows which are beneficial for the aquaculture industry are maintained under Basslink.

5.8.3 Downstream John Butters Basslink Environmental Issues and Mitigation Options

Although subtle changes due to Basslink are identified in the investigations undertaken for downstream John Butters Power Stations, none of the potential changes are believed to create significant management issues. The areas of impact appear to be only to the water quality and geomorphology, and these changes are speculative and fairly minor.

- *Basslink Trends for Water Quality* – Slight increase in the fluctuations affecting dilution and cold water inputs. Potential increase in frequency of high concentration metal plumes due to more frequent operation of the power station.
- *Basslink Trends for Geomorphology* – Possible increase in removal rate of tailings in river bed due to increased scour, and increased occurrence of small turbid plumes, both due to power station turning on more often.

Metal-laden and turbid plumes, related to drainage from the Mount Lyell mining lease and tailings storages in the King River, are a regular feature of the King River downstream of the Queen River. An increased number of short power station shutdowns under Basslink lessens the severity of these occurrences, as under present conditions the greatest concern arises with long power station shutdowns which increase the metal concentrations in these plumes. Consequently, no mitigation measures are proposed for Basslink changes to the John Butters Power Station.

Basslink results in a positive trend for Macquarie Harbour, because King and Gordon freshwater inflows are more coincidental (similar to natural proportions), which lessens the probabilities of metal-laden King River plumes extending far into the harbour.

Some uncertainties in the degree of change, such as with the increased occurrence of discoloured water in the King River, will require ongoing monitoring. Because of the absence of significant management issues, no mitigation options in relation to Basslink are required for downstream of the John Butters Power Station.

Because of the changes in activity in the King River catchment over time (e.g. Abt Railway, Mount Lyell water quality remediation initiatives), it will be important to monitor environmental issues in the King River and Macquarie Harbour, and the Hydro Tasmania Water Management Review will provide a good forum for reconsidering John Butters Power Station operations in light of future changes.

5.9 King Basslink Monitoring

5.9.1 Overview

This section considers what monitoring activities will continue to be undertaken if the Basslink project is approved. The purpose of the monitoring program is to establish the existing conditions downstream of the John Butters Power Station; assess the changes (short- or long-term) caused by Basslink operations; and determine the effectiveness of any mitigation measures applied.

A small number of hydrological monitoring sites exist for the area downstream of John Butters. The locations of the hydrological monitoring sites downstream of Poatina are listed in Table 5.2. It will be important for future Basslink monitoring that comprehensive hydrological data continue to be available.

The following sections list, firstly, the proposed monitoring program and, secondly, provide a discussion of possible future studies.

5.9.2 King Basslink Monitoring Program

The King Basslink Monitoring Program, which will be included in the Basslink mitigation package, will include elements of water quality, fluvial geomorphology, macroinvertebrates, and fish. The proposed program will include an on-site field component operating over approximately eight years (three years pre- and five years post-Basslink), additional data analysis from existing monitoring facilities, and a 5 and 10 year post-Basslink aerial photography program. Almost all of the elements to be monitored will rely on accurate hydrological data for analysis of monitoring results. The existing permanent hydrological monitoring stations should be maintained for the duration of the major elements of the monitoring program.

The suggested **water quality** monitoring is presently being carried out under the Waterway Health Monitoring Program and will continue pre- and post-Basslink.

Fluvial geomorphology monitoring (see Section 5.3.6) includes channel cross-section surveys prior to and five years post-Basslink. This work will be supported by concurrent aerial photos.

Monitoring activities also include repeat photo monitoring and measurement of erosion pins prior to Basslink and at two yearly intervals post Basslink.

Should turbidity in the King River become an issue of concern under Basslink operations, a suspended sediment sampling program will be initiated.

The **instream biota** monitoring (Section 5.5.2.5) includes:

- twice yearly macroinvertebrate sampling at the existing King River site upstream of the Queen River junction, as well as for reference sites, such as the Franklin and Jane Rivers; and
- twice yearly fish sampling in the King River and three reference sites.

The King Basslink Monitoring Program forms an integral part of the Basslink Monitoring Program. The annual cost of the proposed program is estimated to be in the order of $32,000.

Table 5.5 lists the approximate schedule and activities required for each visit, for each monitoring element.

5.9.3 Further Studies

A number of researchers flagged areas of research which may provide valuable information about operational effects and related processes. These are listed in Sections 5.2.2.7.3 and 5.5.2.5.3. These research areas are beyond the scope of the Basslink Monitoring Program, but they may be considered for inclusion in any further studies undertaken in the King River.

5.10 Conclusions from Downstream John Butters Investigations

In conclusion, Basslink changes to the waterways downstream of the John Butters Power Station are relatively subtle, and none of the potential changes are believed to create significant management issues. Possible impacts on water quality and geomorphology are speculative and fairly minor. No mitigation measures for downstream John Butters Power Station are proposed to accompany the Basslink development. However, because of uncertainties in the degree of change, such as with the increased occurrence of discoloured water in the King River, Hydro Tasmania is committed to implementation of an ongoing Basslink monitoring program for downstream John Butters.

Hydro Tasmania’s Water Management Review will provide a good forum for reconsidering John Butters Power Station operations in light of future changes to catchment, riverine and harbour activities.

Table 5.5 Summary of King Basslink Monitoring Program Activities

Element	**Parameter**	**Location**	**Frequency**	**Timing**	**Notes**
Hydrology	stage height	See Table 5.1	continuous		sites should be maintained for the duration of the monitoring program
Water Quality	Water temperature, dissolved oxygen	PS tailrace	continuous		site should be maintained for the duration of the monitoring program
	Copper levels	Lake Burbury	WHMP schedule		ensure WHMP monitoring continues for duration of King Basslink Monitoring Program
Fluvial Geomorph.	aerial photography	King River downstream of power station	5 & 10 years post-Basslink	PS shut-down	
	channel cross sections	13 cross sections of the King River, from the Quarter Mile Bridge to the delta	once pre- and 5 years post-Basslink	PS shut-down	
	Erosion pins and photo monitoring	as above	Basslink –1, +1, 3 & 5 years	PS shut-down	
Macroinvertebrates	RAP methods	existing King R. site & reference sites	twice per annum, 3 yrs pre- & 3 yrs post-Basslink	Oct & April	compare with results of present study
Fish	spp, distribution, CPUE	King R. u/s Queen R. & 3 reference sites	twice per annum, 3 yrs pre- & 3 yrs post-Basslink	Dec & April	

6 TEMSIM SENSITIVITY ANALYSES

6.1 Purpose of the Review

The Basslink Scoping Report (Appendix 1 of this report series, referred to as the ‘Scoping Report’ for the remainder of Section 6) examined the effects of several different Basslink cable sizes on the Tasmanian generating system, as neither the proponent nor the exact cable size had at that stage been identified. In February 2000 the proponent for the Basslink cable was announced, along with the proposed cable specifications. This led to an update of the TEMSIM model using the specifications provided by the proponent, National Grid International Limited (NGIL).

In external reviews of the Scoping Report, a number of queries were raised with regard to the effects of key variables used in the assumptions. The two variables which would have the greatest impact on Hydro Tasmania system operations with Basslink were identified as the Tasmanian load and the Victorian spot price projection. The Tasmanian load influences the net energy balance in Tasmania, and hence the net load on the Hydro Tasmania system and the net energy available for transfer on Basslink. The Victorian price is the primary driver of short-term variability in Basslink flows.

The TEMSIM Sensitivity Study on the Implications of Basslink (Appendix 29) was written with several purposes:

a) To identify any additional variations to the model predictions arising from the changes to the Basslink parameters that were used in Basslink Environmental Scoping study (Appendix 1 of this report series);

b) To evaluate the effects of Basslink on the Tasmanian system with different Victorian Prices and Tasmanian Load; and

c) To test the robustness and representative nature of the Tasmanian Electricity Market Simulation Model (TEMSIM).

This section presents the details and results of this review. Section 6.2 details the specifications of the Basslink cable and updated TEMSIM model assumptions as compared to that assessed in the Scoping Report (Appendix 1). Section 6.3 presents the results of analyses comparing TEMSIM model runs from the Scoping Report for the 450 MW cable size with the updated model assumptions. Section 6.4 presents the results of sensitivity analyses for changes in load, and Section 6.5 presents the results of sensitivity analyses for changes in price.

Section 6.6 discusses the implications of the outcomes of this review for the conclusions drawn from the environmental studies presented in Sections 3, 4 and 5.

6.2 Updated Model Assumptions

Once the cable capacity was known, the TEMSIM model as parameterised for the Scoping Report (Appendix 1) was modified and comparative analyses between the new model results and those used in the Scoping Report were completed. The major changes to the Final Basslink Case assessed in this TEMSIM sensitivity analysis compared that used for the Scoping Report are summarised in Table 6.1.

Table 6.1 Assumptions Used in Scoping Report TEMSIM Model Run versus Final Basslink Case TEMSIM Model Runs

Specification	Scoping Report	Final Basslink Case
Cable Size	**300 MW, 450 MW & 600 MW**	480 MW
Import vs. Export	Equal import and export	604 MW export / 302 MW import
Transmission Losses	10% import and export	12.6% export / -5.0% import

The transmission losses used for the Final Basslink Case are based on the results of a detailed system analysis, and relate to losses between the Tasmanian and Victorian Regional Reference Nodes (RRNs, located at Georgetown, Tasmania and Thomastown, Melbourne respectively). The marginal loss factor between the Thomastown RRN and the Basslink connection point at Loy Yang in Victoria results in negative losses on import of electricity to Tasmania.

Another change was the system start storage for the runs which began the 1st January 2003. The start storage position on the 1st January 2003 for the Scoping Report was based on January 1999 storage levels, whereas for the Final Basslink Case was based on January 2000 storage levels. Inflows to the system were lower than average during 1999, so the start storage estimate for the Final Basslink Case is lower than that used for the Scoping Report.

Other key assumptions for the base case runs unchanged from the Scoping Report, including a Tasmanian net system load of 1135 MW (which is based on the projected 2003 Tasmanian load, based on 1999 load forecast and new supply options such as wind power), Victorian prices based on Proph_02, no cloud seeding and no Bell Bay (Basslink provides the system security previously provided by Bell Bay). These are the same assumptions used for the Scoping Report.

6.3 Comparison of Outcomes with Conclusions in the Scoping Report

Comparisons were made between the Scoping Report 450 MW case and the Final Basslink Case described above, with the two cases referred to respectively as the “Scoping 450” and the “Base” cases in Figure 6.1 to Figure 6.4. The results indicate little change between the two cases. Figure 6.1, Figure 6.2, Figure 6.3 and Figure 6.4 examine the differences between the two cases for Lake Gordon levels and the Gordon Power Station discharges.

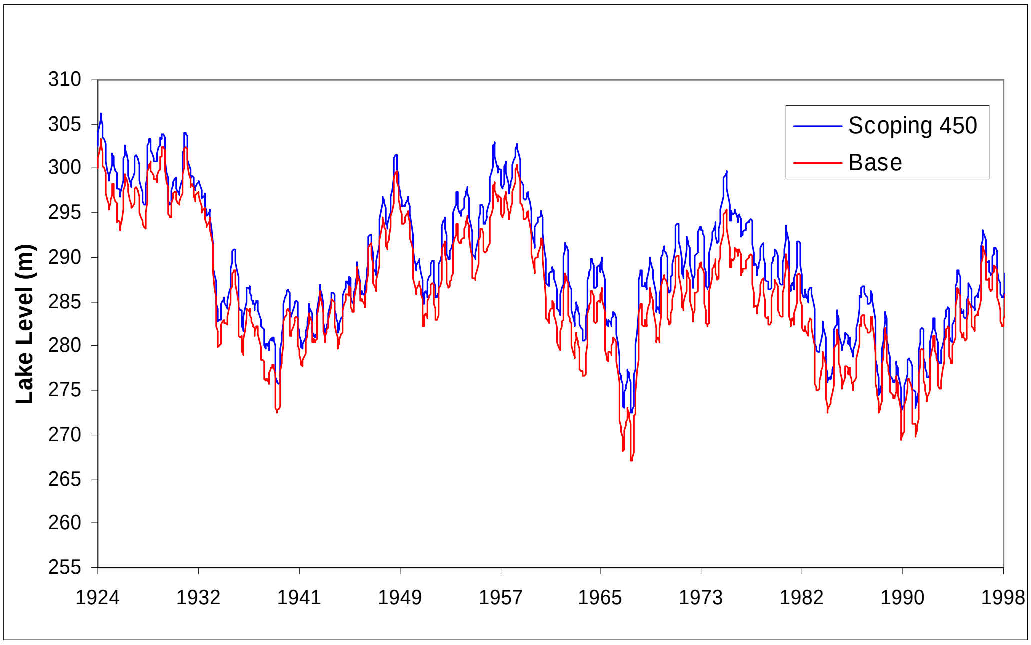


Figure 6.1 Historical Period Simulated Lake Gordon Level

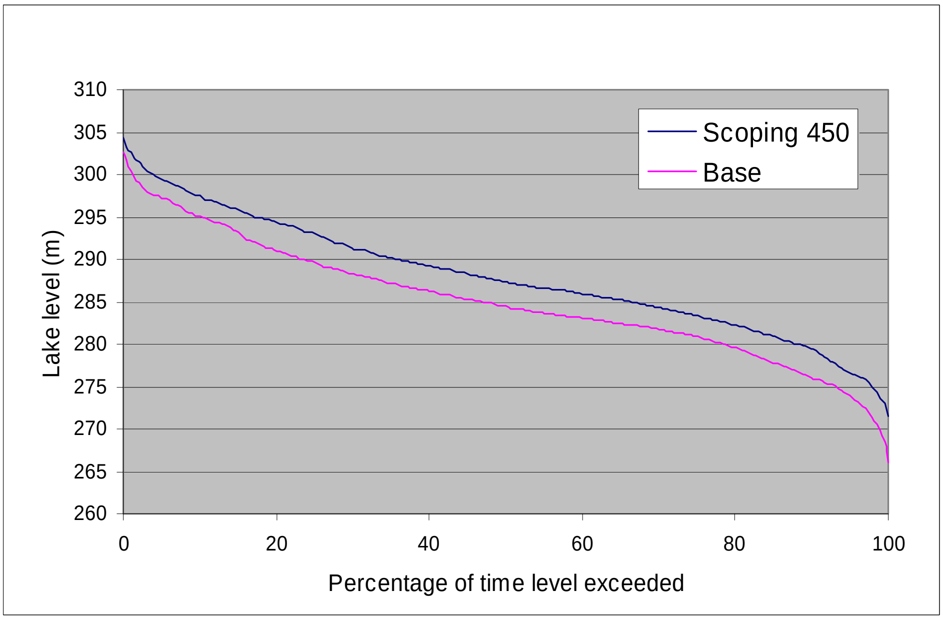


Figure 6.2 Duration Curve of Lake Gordon Level

The lower lake levels shown in Figure 6.2 can be attributed entirely to the lower start storage position used for the Base case compared to the Scoping 450 case. This is illustrated by the lack of difference in the Gordon Power Station discharges between the two cases (Figure 6.3).

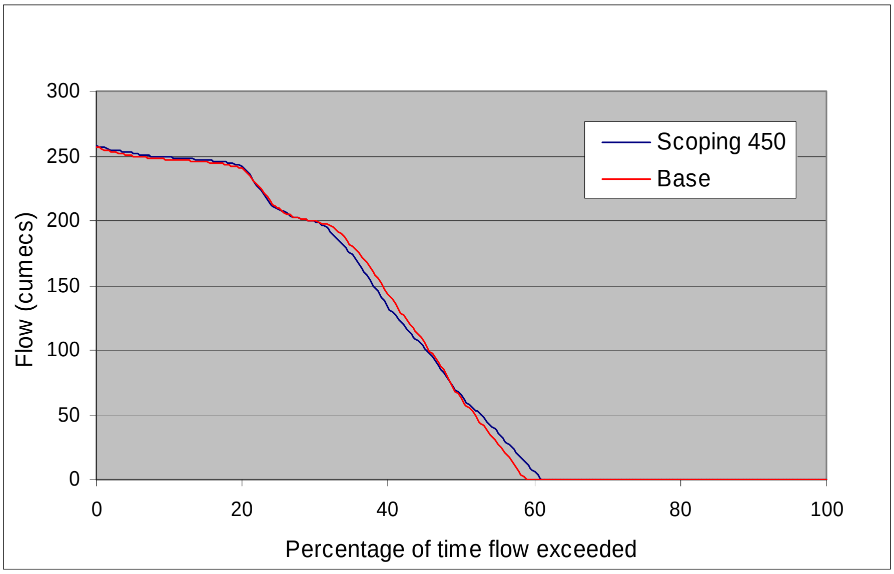


Figure 6.3 Duration Curve of Downstream Gordon Power Station Flows

There are some slight differences in the monthly median flows shown in Figure 6.4, showing a slightly stronger bimodal pattern, with higher June discharges but lower July discharges. Note in Figure 6.4, the label "HEC (2000)" refers to the Scoping 450 case.

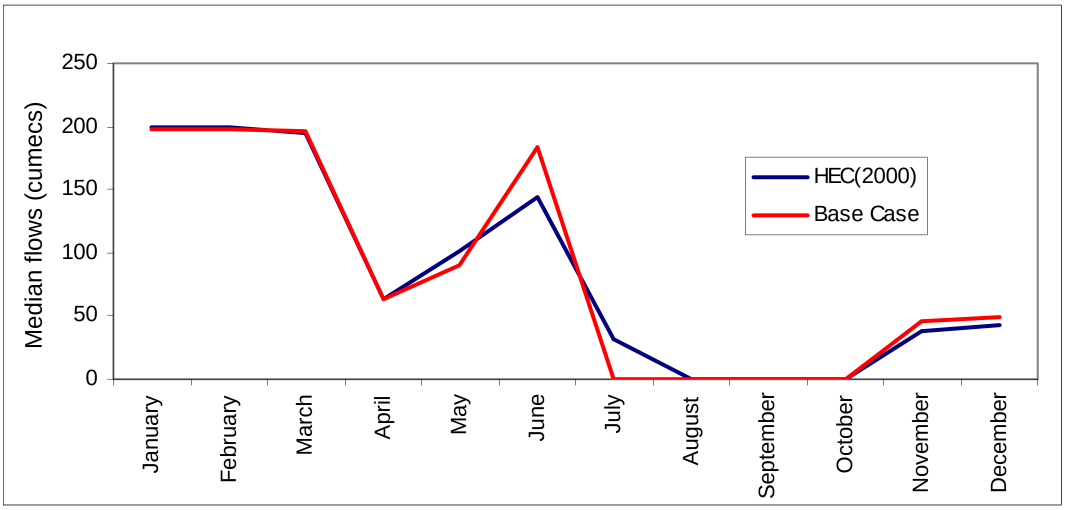


Figure 6.4 Median Monthly Flow from Gordon Power Station.

Similar results were found for Poatina and John Butters power stations and the corresponding lakes, with a marginal change in the flows for Poatina Power Station.

In conclusion, there are no significant changes predicted in the system operation for the Basslink cable with its known specifications as announced by NGIL, compared to that predicted to occur in the Scoping Report (Appendix 1) for the 450 MW cable.

It should be noted that all of the hydrological analyses conducted subsequent to the Scoping Report and presented in this report series (Appendix 2 for Gordon, Appendix 15 for Poatina and Appendix 22 for John Butters) were based on analyses of output using Final Basslink Case model runs.

6.4 Sensitivity of the TEMSIM Model to Load Changes

The change in Tasmanian load affects the amount of energy available for export. As load increases, the storages start to deplete, hence increasing the water values and affecting the level of imports and exports across the Basslink cable.

The scenarios of Tasmanian load were examined:

1. Long-term average load = 1100 MW;
2. The Scoping 450 Case and Final Basslink Case load of 1135 MW; and
3. Economic rating of the system = 1151 MW.

The 'Long-term average load' is that which can be supplied by the existing Hydro Tasmania system with a 98% reliability of supply, i.e. no thermal support. The reliability of supply is based on maintaining a specified Energy in Storage, ie. an emergency level.

The 'Economic rating of the system' is the load which can be supplied with thermal support, and based on a defined load shortfall probability.

For these sensitivity analyses, the Final Basslink Case assumptions are utilised (see Section 6.2), with only the load being changed. Where 'Base Case' appears in the remaining figures in Section 6, it refers to the Final Basslink Case.

The results of the comparison showed variation in lake levels in the major storages when the load is changed. As load increases lake levels in Great Lake and Lake Gordon are reduced, as shown in Figure 6.5 and Figure 6.6. For a lower load (the 1100 MW case), marginally higher storage levels are observed. When the Tasmanian load is relatively low, storage levels increase and the water value decreases, however the level of exports predicted to occur is not sufficient to drive lake levels lower than that predicted for a higher load.

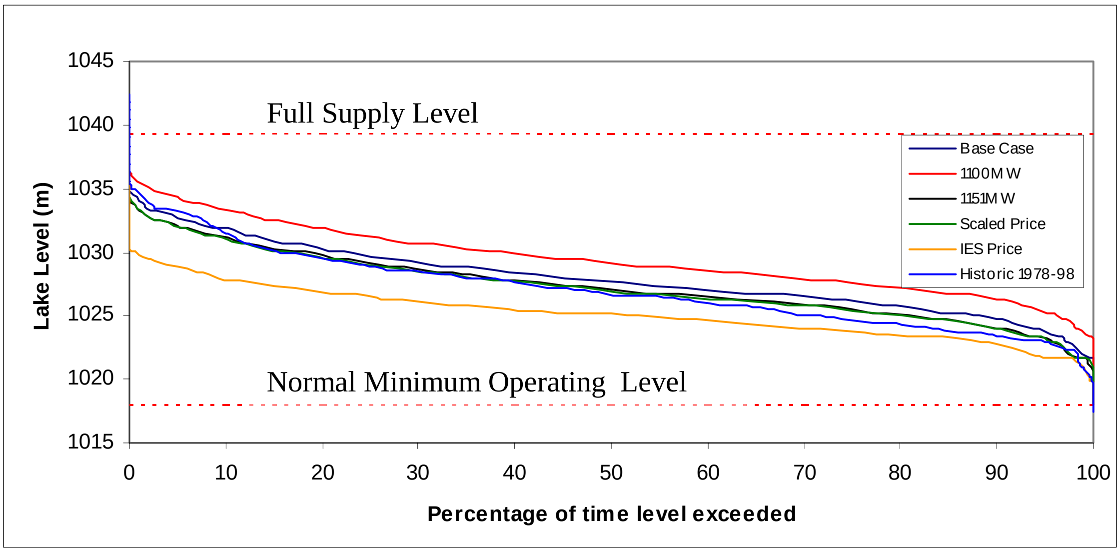


Figure 6.5 Great Lake Level Analysis

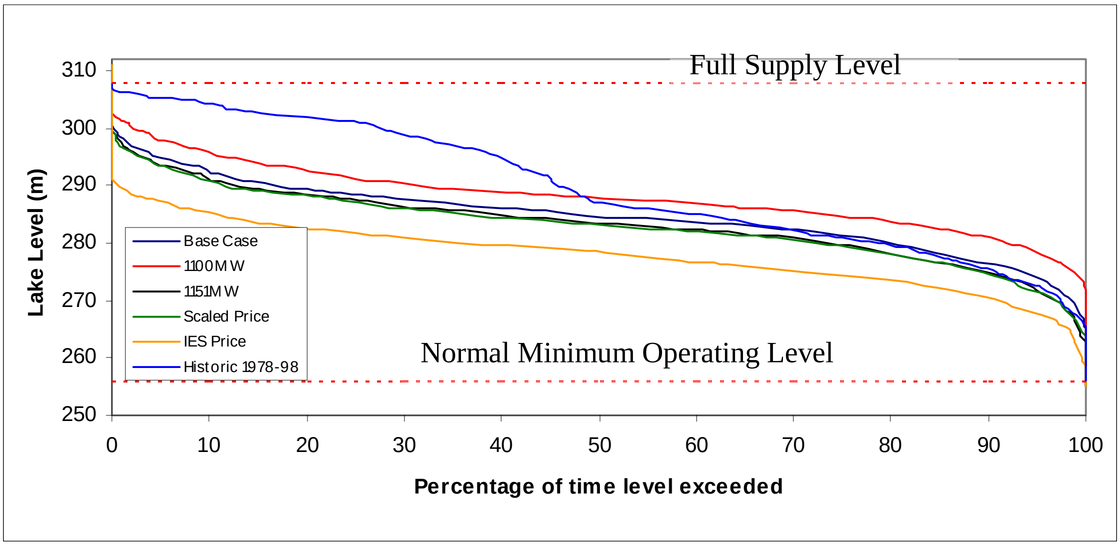


Figure 6.6 Lake Gordon Level Analysis

There was little to no change in the predicted power station flows with changing load, as shown in Figure 6.7 to Figure 6.10.

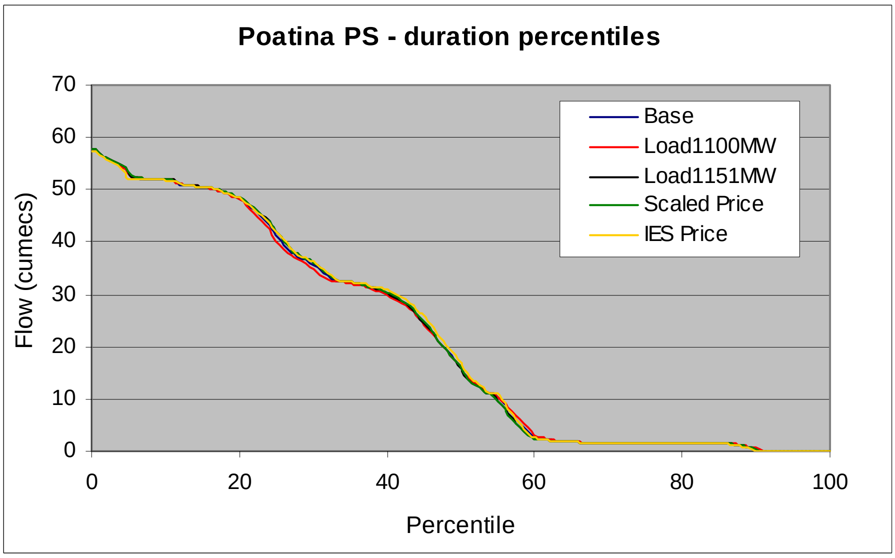


Figure 6.7 Poatina Power Station Downstream Discharge

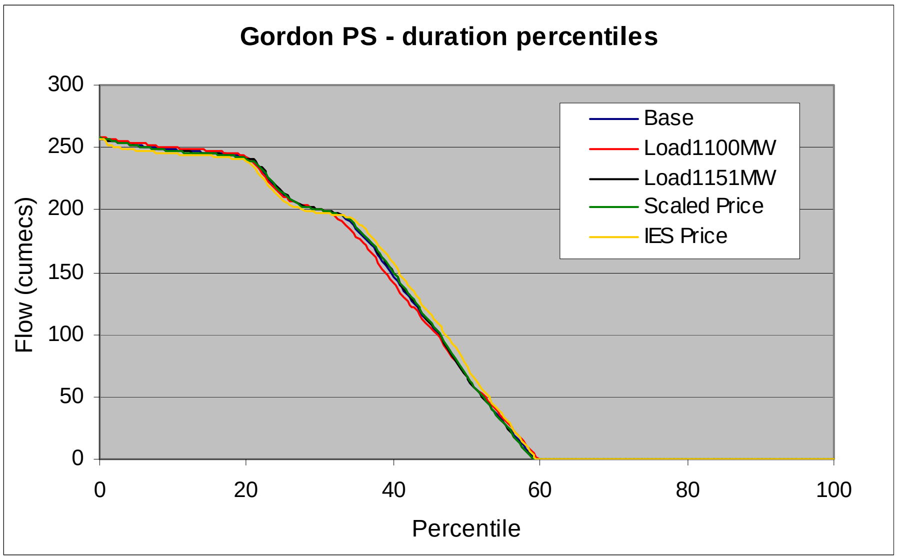


Figure 6.8 Gordon Power Station Downstream Discharge

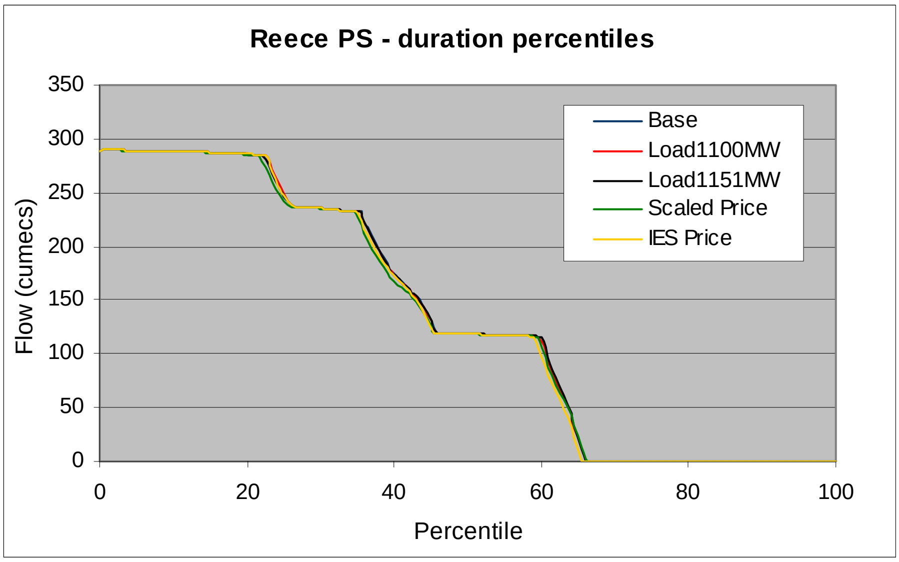


Figure 6.9 Reece Power Station Downstream Discharge

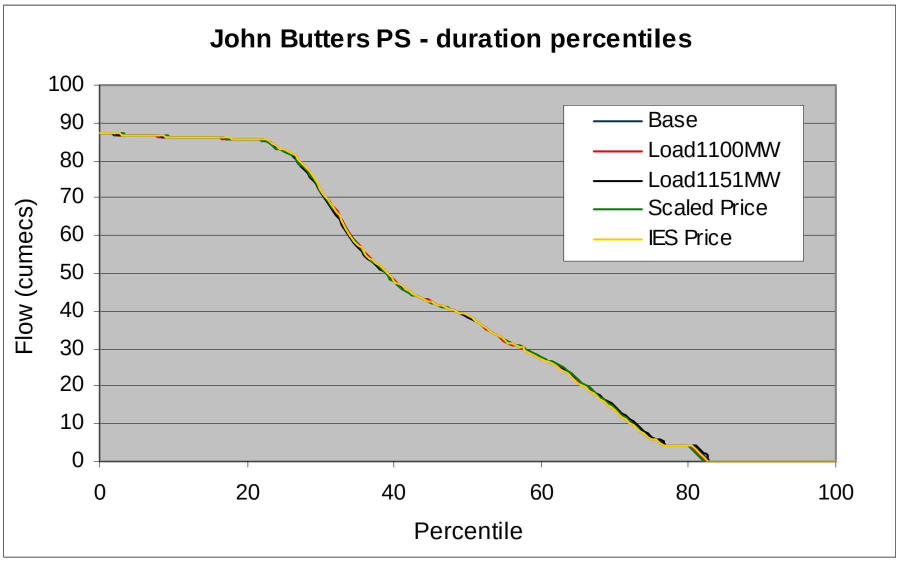


Figure 6.10 John Butters Power Station Downstream Discharge

This shows that under a higher Tasmanian load, the same amount of energy is being produced by the Hydro Tasmania generating system as this is essentially determined by hydrological inflows, but additional energy is being imported to Tasmania by Basslink to meet the Tasmanian load. In other words, under the three different load scenarios a similar amount of energy is being produced by the Tasmanian generators, with the difference in demand and supply being made up by either additional imports or exports. It is quite likely that by increasing the load, most of the increase will be made up of more imports or a reduction in exports. Therefore, generation patterns in Tasmania under Basslink are largely insensitive to Tasmanian load changes.

With lower Tasmanian load and higher storages (refer to Figure 6.5 and Figure 6.6), it would be expected to see higher net exports or lower net imports. These do occur, but they do not affect the magnitude and hourly variability of export and import flows, because these are driven by the Victorian Prices variation. Thus in the lower load cases, the storages tend to fill, the water value tends to decrease and some additional export flows or reduced import flows are seen. Increased hydro production tends to reduce the storage levels and the probability of spill. Overall, a new ‘equilibrium’ is reached as a consequence of lower Tasmanian loads on the Hydro Tasmania system, with storages slightly higher and spot prices slightly lower when compared with the higher loads (Figure 6.5 and Figure 6.6).

6.5 Sensitivity of the TEMSIM Model to Price Changes

In these sensitivity analyses, all prices were derived using the PROPHET model (see Section 2.3.1), using the same assumptions as used for the Scoping Report prices. The PROPHET model intricately models all generators in the mainland market and includes bidding policies for each generator, allowing a realistic price sequence to be produced given the bidding policies adopted.

Three price scenarios were examined:

1. PROPH-02 - the price scenario used for the Scoping 450 and the Final Basslink cases (referred to as the ‘Base Case’ in Table 6.2 and Figure 6.11);
2. PROPH-02a – the ‘Scaled Price’ scenario, which is the PROPH-02 scenario with price peaks and troughs arbitrarily scaled up and down to represent a highly variable but a realistic pricing pattern; and

3. PROPH-33 – the 'IES Price' scenario, derived by Intelligent Energy Systems.

Table 6.2 shows general statistics on the three different price scenarios.

Table 6.2 Statistics on Price Scenarios Examined

Price scenario	MEAN ($/MWH)	St Dev ($/MWh)	Median ($MWh)
Base Case (PROPH-02)	**27.5**	30.9	21.6
Scaled Price (PROPH-02A)	27.8	40.2	20.1
IES Price (PROPH-33)	28.3	26.8	22.7

All three scenarios have reasonably close means and medians, but very different standard deviations. The standard deviations reflect the level of price fluctuation, which is highest with the Scaled Price scenario.

Average monthly Victorian prices for the three scenarios are shown in Figure 6.11 for a two year period selected at random, from Jan 1924 to December 1926. The IES price pattern is distinctly different from the other two scenarios, with reduced extreme values and a more constant annual price.

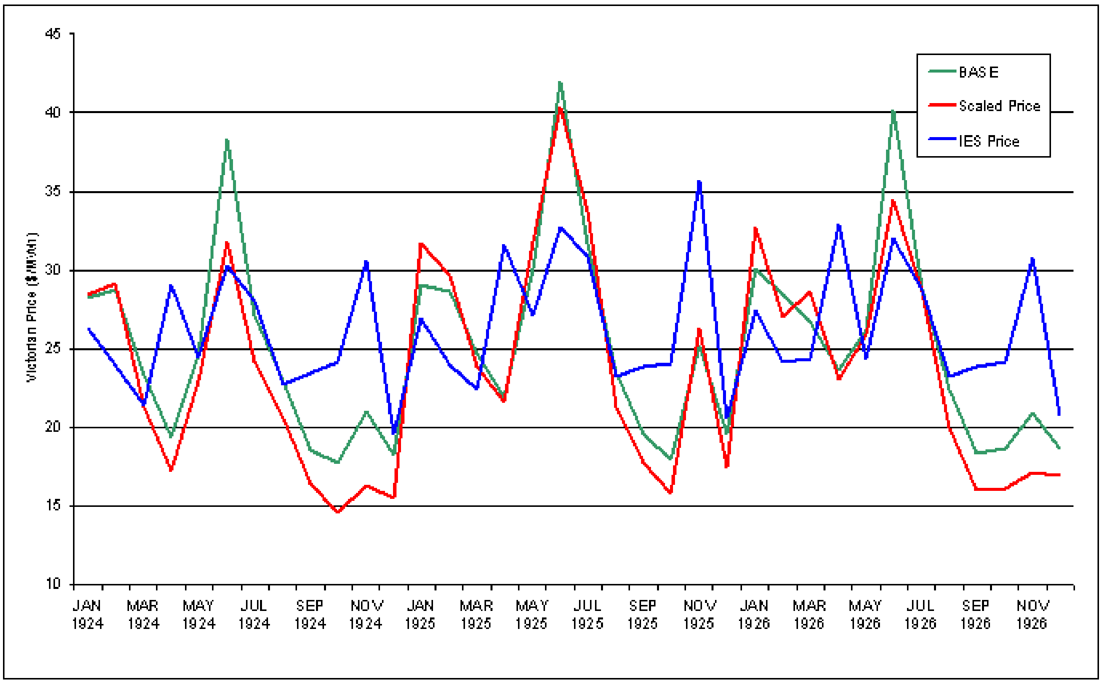


Figure 6.11 Victorian Price Variation for Different Price Sensitivity Cases

If price variability was the primary driver for the on-offs of the major power stations, then the Scaled Price scenario would provide the highest variability in downstream flows. However, Victorian price is not the primary driver under all conditions (the influence of Victorian price on import and export patterns was discussed in Section 2.3.1). Victorian price is a strong influence on daily import/export patterns if Tasmania is not extremely wet or dry. However, the daily patterns are underlain by seasonal and inter-annual patterns that are not influenced by the Victorian price. Seasonal import/export patterns are most strongly affected by seasonal rainfall patterns in Tasmania, that is, whether or not it is a dry or wet summer or winter. Inter-annual patterns are most strongly affected by the overall balance between supply (i.e. system capacity) and demand (i.e. the Tasmanian load).

The results of the sensitivity analyses to Victorian price, shown in Figure 6.5 and Figure 6.6, showed that the IES Price scenario resulted in a reduction in lake levels of the major storages as compared to the base case price scenario. The majority of change is attributed to the start conditions of the analysis and the different within year price patterns of the IES price case. After the initial period of modelling, lake level variation was found to be marginal, although the IES price case was always lower than the Final Basslink Case by 5-8 m for Lake Gordon and 2-5 m for Great Lake.

The changes in lake levels with the different price scenarios were accompanied by very little change in the downstream power station flow duration curves (see Figure 6.7 to Figure 6.10). There were slight variations in the timing of power station discharges between the different price scenarios, with annual time series showing increased generation in the September to November period for Gordon and Poatina during wet years for the IES price scenario compared with the other price scenarios (little change was shown for dry years). The IES price is less variable, which would equate to less variable power station scheduling if it were accompanied by low variability in water availability. Flow event and zero event analyses for the Gordon Power Station showed no significant changes in flow events for the different cases.

6.6 Conclusions of TEMSIM Sensitivity Analyses and Implications for Basslink Research Conclusions

6.6.1 Purpose and Scope of the Review

As stated in Section 6.1, the Temsim Sensitivity Study report (Appendix 29) was written with several purposes:

a) To identify any additional variations to the model predictions arising from the changes to the Basslink parameters that were used in Basslink Environmental Scoping study (Appendix 1 of this report series);

b) To evaluate the effects of Basslink on the Tasmanian system with different Victorian Prices and Tasmanian Load; and

c) To test the robustness and representative nature of the Tasmanian Electricity Market Simulation Model (TEMSIM).

This study was not as comprehensive as that undertaken for the Scoping Report (Appendix 1), with only the major storages and two head water storages being investigated. The primary reasons for limiting this study were:

- The changes examined are unlikely to affect the minor storages in the system, due to the limited amount of discretion on the usage of the inflow water (ie use it or spill it); and
- As all head water storages are operated interdependently, there is little point in modelling all head water storages, as they react and are operated in the same manner.

The review achieved all of its intended purposes.

6.6.2 Variations from Scoping 450 MW Case Conclusions

This study did not identify any further variations to the model predictions for the new Basslink parameters compared to those indicated in the Scoping Report (Appendix 1). No significant difference in the downstream power station flows of the major storages or the head storages was identified in comparison of the Scoping 450 and Final Basslink cases.

6.6.3 Effects of Varying Tasmanian Load and Victorian Price

These results indicated no significant additional concerns when examining differing loads or Victorian prices.

The use of the IES price scenario showed some significant variations in predicted lake levels compared to the other price scenarios. The IES price scenario showed a lowering of lake levels for the major storages by 5-8 m for Lake Gordon (within its operating range of 52 m), and 2-5 m for Great Lake (within its operating range of 21 m), compared to the Final Basslink case. There was little difference in the corresponding downstream power station flows. The lower lake levels were seen to be due to a combination of the price scenario and the starting conditions, which lead to an initial draw down of the major storages.

There was also a change in the major storage levels for a lower Tasmanian load, with marginally higher storage levels being observed. In this case there were additional exports with the additional energy available, however the pricing signals were not significant enough to cause all the additional energy to be exported.

In all the varying load and price scenarios, the downstream power station flows showed little change. The primary reason is that there is only a certain amount of water available to be released and the variation in load and price only changes the timing of the releases.

6.6.4 Robustness and Representability of the TEMSIM Model

Overall TEMSIM appears to produce results that reflect the influence of outside drivers such as price and load. On inspection of the results, the results appear to be representative of what could occur if such conditions of price and load existed. This indicates that TEMSIM is a robust model of the Tasmanian System under Basslink, providing insight into the problems which may exist in such a system.

This study also highlighted the system dependence on the ability to store the highly variable inflows. Even in the case of storages with high discretionary water value (ie head storages), there was minimal effect on the lake levels or downstream power station flows.

Provided there are no significant changes in the market structure (ie more regional reference nodes), system (additional generation or transmission lines) or risk profile (level of risk taken by Hydro Tasmania), TEMSIM adequately highlights the areas of change in operation of the generating system that are likely to arise with Basslink.

6.6.5 Implications for the Basslink Environmental Conclusions

In conclusion, the review of the TEMSIM model provides confidence in the use of TEMSIM predictions as a basis for the Hydro Tasmania Basslink environmental investigations. The model is robust, and provides logical responses to changes in key parameters.

Several possibilities were raised in this review, for example if Tasmanian load or Victorian price with Basslink are different than the assumptions in the Final Basslink Case. Marginally higher storage levels were indicated if the Tasmanian load is lower than that used in the Final Basslink case. The IES price scenario showed a lowering of lake levels for the major storages by 5-8 m for Lake Gordon (within its operating range of 52 m), and 2-5 m for Great Lake (within its operating range of 21 m), compared to the Final Basslink case. These possible changes are not considered significant, as the lakes are still operated well within their historical ranges. None of the possible changes in load or price influenced the predicted power station discharge patterns significantly enough to reconsider the scope or conclusions from the environmental research presented in this report series.

The only significant issue with the use of the TEMSIM model is the indications from the model runs that Basslink will result in more full gate discharge from the power stations compared to existing conditions. This has been discussed previously in this report (Section 2.3.2), and reflects the present coarseness of the bidding modules in TEMSIM, which are on a power station-by-power station basis rather than a machine-by-machine basis (i.e. individual generators). The TEMSIM predictions of increased full-gate power station discharges due to Basslink are considered to be an over-estimate.

The environmental researchers were asked to identify potential environmental impacts of Basslink based on the TEMSIM predictions of Hydro Tasmania system operations. The conclusions of the research areas were summarised in Sections 3.9.2, 4.8.2 and 5.8.2. The areas anticipated to show negative environmental responses to the Basslink development are the Gordon River Fluvial Geomorphology, Gordon River Riparian Vegetation, Gordon River Macroinvertebrates, Gordon River Fish, Downstream Poatina Water Quality, Downstream Poatina Fluvial Geomorphology, Downstream Poatina Socio-Economic Issues, King River Water Quality and King River Fluvial Geomorphology.

Re-examination of these conclusions shows that environmental issues raised in four of these areas relate specifically to the prediction of increased full gate discharges. These are shown in bold below:

- *Basslink Trends for Gordon Fluvial Geomorphology* – Basslink will result in changes to the geomorphic processes controlling stability of the Gordon River banks, notably with **an increase in the probabilities of scour**, and an alteration to conditions leading to bank saturation, thus modifying seepage erosion processes. Basslink changes are anticipated to be limited to adjustments of alluvial bank profiles, but no change to river planform compared to existing effects of flow regulation.
- *Basslink Trends for Gordon Riparian Vegetation* – Accelerates rates of present trends, but results in the same end-point as existing regime for the river banks u/s of the Splits between LWM and 1.5 m. Accelerated decline of island vegetation. **Existing zone of predominantly mineral substrate from LWM to 1.5 m will increase in extent to reach 2.5 m on the bank. Existing 1.5-2.5 m zone migrates up to occupy 2.5-4 m zone, lose existing 2.5-4 m zone**. No changes above 4 m due to Basslink. Changes to the risk of inundation and waterlogging should occur, however the lack of regeneration and recruitment means the majority of the vegetation, particularly u/s of the Splits, to a height of approximately 2.5 m above LWM, will die and not be replaced in the long-term. Longitudinal extent of impacts remains the same as for existing conditions.
- *Basslink Trends for Poatina Fluvial Geomorphology* – A change in the nature of the existing channel degradation processes in Brumbys Creek, which will experience a switch in erosion mechanism from seepage-induced draw-down failures to scour of toe and bed leading to slumping. In upper Macquarie (Canola Clay soils), **increase in wetting-drying cycles in upper portion of banks will increase definition of a step in this part of the bank**; this could be colonised by grasses tolerant of frequent short-term inundation. In sandier soils in the Macquarie and South Esk rivers, **potential for increase in scour, undercutting** and small-scale failures.

- *Basslink Trends for King River Geomorphology* – **Possible increase in removal rate of tailings in river bed due to increased scour**, and increased occurrence of small turbid plumes, both due to power station turning on more often.

The bold parts of the above predictions of Basslink changes are believed to be overstatements of impact because of the model bias which over-estimates full capacity power station discharges, and in fact the Basslink changes will be less than indicated.

The TEMSIM model is the best predictive tool available for analysis of Basslink changes on the Hydro Tasmania generating system. By understanding the assumptions and limitations of these modelled predictions, a better understanding can be gained of the likely environmental impacts due to Basslink.

7 SUMMARY OF IMPACTS OF HYDRO WATER MANAGEMENT CHANGES DUE TO BASSLINK

7.1 Scope of Investigations

Hydro Tasmania has undertaken extensive investigations into the potential changes to generating system operations due to a Basslink cable, and the environmental implications of these changes. Basslink would connect the Tasmanian electricity system to the National Electricity Market, and change the way the Hydro Tasmania system is operated.

Various reports have been commissioned since the early 1990s, examining the feasibility and potential environmental and social issues associated with a Basslink cable. More intensive model development and analyses were undertaken by Hydro Tasmania in the late 1990s, and since a proponent was announced for the Basslink project in February 2000, on-ground environmental investigations of potential implications of Basslink were increased in scale. In total, Hydro Tasmania has committed $2.5 million to the investigation of environmental issues for Tasmanian waterways associated with the Basslink development.

Results of analyses using a predictive model known as TEMSIM (Tasmanian Electricity Market Simulation Model) showed that only three power stations in the State had significantly different patterns of operation with Basslink. These are the Gordon Power Station in the southwest of the State, the Poatina Power Station in the north-central part of the State, and the John Butters Power Station in the middle of the West Coast.

7.2 Hydro Tasmania Water Management Changes under Basslink

In general, Basslink is projected to increase the on-off operation of the Gordon, Poatina and John Butters power stations throughout the full range of discharges, result in more winter discharge than at present, and increase the occurrence of high power station discharges (although this is over-estimated due to a model bias). Increased occurrence of weekend shutdowns for Gordon and Poatina is also indicated by the model runs. Variability between years in patterns of power station operation is likely to be reduced. Changes are most significant for the Gordon and Poatina power stations, and less so for the John Butters Power Station.

No significant changes are indicated by the modelled results for any of the lakes in the Hydro Tasmania generating system, and existing lake level agreements will continue with or without the commissioning of Basslink. Basslink results suggest that average monthly lake levels for Lake Gordon, Great Lake and Lake Burbury are held somewhat lower than their historical ranges, by 1-2 m for Great Lake and Lake Burbury, and 3-4 m for Lake Gordon, and tend to fluctuate over a narrower range than historical. This is not considered to be significant, given that it is within the normal operating range for the lakes, and for the major storages presents only a very small change from the very large operating ranges (52 m for Lake Gordon, 21 m for Great Lake, 9 m for Lake Burbury).

A bias in the TEMSIM model makes predicted patterns of water discharge under a Basslink operating regime appear very “blocky” and extreme in range, going from zero discharge (power station shutdown) to full capacity discharge to zero discharge without utilising intermediate discharge levels. To be conservative, researchers for these investigations were asked to assess the environmental implications of Basslink with the given TEMSIM predictions, and so environmental impacts particularly where they relate to increased full capacity discharges under Basslink are likely to be over-estimated.

7.3 Basslink Environmental Management Issues

7.3.1 Gordon River

Environmental investigations on the Gordon River encompassed hydrology, water quality, fluvial geomorphology, karst, riparian vegetation, macroinvertebrates and aquatic mammals, fish, terrestrial fauna, cave biota, meromictic lakes, cultural heritage, public use and World Heritage Area values.

Environmental impacts with the Basslink development, in the absence of the substantial mitigation measures to which Hydro Tasmania commits, were indicated from the investigations to relate to four areas of study:

- **Fluvial Geomorphology:** Basslink is predicted to change the geomorphic processes controlling stability of the Gordon River banks relative to the present processes. Notably, this will be an increase in the probabilities of scour (this is believed to be over-estimated because of the TEMSIM model bias of increased full capacity power station discharge), and an alteration to conditions leading to bank saturation, thus modifying seepage erosion processes. The average annual number of drawdown events increases significantly with Basslink, which may lead to an increase in the occurrence of seepage-induced erosion, but probably not an increase in severity because banks are less saturated. Basslink changes are anticipated to be limited to adjustments of alluvial bank profiles, but no change to river planform compared to existing effects of flow regulation.

- **Riparian Vegetation:** Basslink is predicted to accelerate present rates of loss of riparian vegetation communities. As part of this, Basslink is projected to cause migration of the existing vertical zonation in the river banks up the bank (also believed to be over-estimated because of the TEMSIM model bias). The majority of the riparian vegetation, particularly upstream of the Splits to a height of 2.5 m above low water mark on the river banks, is anticipated to die and not be replaced in the long-term under existing conditions, and this would not change with Basslink.

- **Aquatic Macroinvertebrates:** Basslink is predicted to alter the community composition of macroinvertebrates in the Middle Gordon River, and further reduce diversity and abundance both upstream and downstream of the Denison River confluence. Follow-on effects may be seen in platypus and native water rats which rely on macroinvertebrates for their food supplies.

- **Fish:** Basslink is predicted to result in reduced availability of fish habitat within Middle Gordon River, and reduced food supplies through impacts on macroinvertebrates may lead to further reduced populations.

Aspects of the Basslink operating regime mitigate against some existing environmental impacts. These include:

- **Water Quality:** Basslink holds Lake Gordon somewhat lower in its operating range compared to historical operations, which reduces the risk of low dissolved oxygen and seasonally cooler water being drawn into the power station intake; and

- **Fish and Platypus Dispersal:** The increased occurrence of short-term and weekend power station shutdowns provides more opportunity for fish passage and platypus dispersal in the Middle Gordon River.

An assessment of Basslink implications on the values for which the Tasmanian Wilderness World Heritage Area was declared concluded that Basslink does not substantially degrade WHA values, and in fact may provide some opportunity to enhance values with the substantial mitigation measures to which Hydro Tasmania commits.

7.3.2 Downstream Poatina Power Station

Environmental investigations downstream of the Poatina Power Station encompassed hydrology, water quality, fluvial geomorphology, instream biota, terrestrial biota, cultural heritage, and landowner issues.

Environmental impacts with the Basslink development, in the absence of the substantial mitigation measures to which Hydro Tasmania commits, were indicated from the investigations to relate to four areas of study:

- **Water Quality:** Basslink is anticipated to cause rivers downstream of Poatina to experience slightly lower summer temperatures, and rapid fluctuations in water quality parameters. Salinity along Brumbys Creek banks will decrease if driven by inundation, but increase if driven by fluctuations.

- **Fluvial Geomorphology:** Basslink is predicted to cause a change in existing channel degradation processes in Brumbys Creek (from seepage-induced draw-down failures to scour of toe and bed leading to slumping). In the clay soils of the Macquarie River downstream of Brumbys Creek, increase in wetting-drying cycles in upper portion of banks will increase definition of a step in this part of the bank. In sandier soils in the Macquarie and South Esk rivers, Basslink presents some potential for increase in scour, undercutting and small-scale failures (again, these impacts may be over-estimated by TEMSIM model bias).

- **Instream Biota:** Basslink is predicted to increase stresses on macrophytes (aquatic plants) in the three existing Brumbys Creek weir ponds downstream of the tailrace (see Map 4), to impact on weir pool ecosystems and fishery productivity, and increase stresses on macroinvertebrates and fish in main channel. Frequent dewatering periods could possibly impact on trout recruitment. Increased occurrence of maximum discharges would also stress the instream biota (believed to be over-estimated). There may also be impacts for platypus but these are unlikely to affect the population as a whole.

- **Socio-Economic Issues:** Basslink is predicted to cause problems for water abstraction by landowners by affecting pump-set ups with the fluctuating flows over the whole power station range and increased power station shutdowns. The risks of stock strandings are increased due to the frequent on-off of the power station. Increased work stresses associated with fluctuating water levels may be an issue for Sevrup Pty. Ltd. Adverse impacts on the recreational trout fishery in Brumbys Creek may arise due to projected impacts on macroinvertebrate food supplies. Increased risks to public safety may be an issue with increased fluctuations in water levels.

Basslink in the absence of mitigation measures is anticipated to improve flow-through, and hence water quality, in Brumbys Creek weir ponds with Poatina off for shorter durations compared to existing conditions.

7.3.3 Downstream John Butters Power Station

Environmental investigations downstream of the John Butters Power Station encompassed hydrology, water quality, fluvial geomorphology, instream biota, cultural heritage, public use, and a water quality assessment of Macquarie Harbour. Although subtle changes due to Basslink are identified in the investigations undertaken for downstream John Butters Power Station, none of the potential changes are believed to create significant management issues. The areas of impact appear to be only to the water quality and geomorphology, and these changes are speculative and fairly minor in proportion to the magnitude of existing environmental issues related to mining impacts:

- **Water Quality:** Basslink is predicted to result in a slight increase in the fluctuations affecting dilution and cold water inputs, and a potential increase in frequency of high concentration metal plumes (originating from the mine lease site) due to more frequent operation of the power station.

- **Fluvial Geomorphology:** Basslink is predicted to result in a possible increase in removal rate of mine tailings in river bed due to increased scour, and increased occurrence of small turbid plumes, both due to the power station turning on more often.

Metal-laden and turbid plumes, related to drainage from the Mount Lyell mining lease and tailings storages in the King River, are a regular feature of the King River downstream of the Queen River. An increased number of short power station shutdowns under Basslink lessens the severity of these occurrences, as under present conditions the greatest concern arises with long power station shutdowns which increase the metal concentrations in these plumes. Consequently, no mitigation measures are proposed for Basslink changes to the John Butters Power Station.

Basslink results in a positive outcome for Macquarie Harbour. King and Gordon freshwater inflows are more coincidental (similar to natural proportions between the two rivers), which lessens the probabilities of metal-laden King River plumes extending far into the harbour.. Modelling work assessing Basslink changes to Macquarie Harbour showed no significant changes to either Macquarie Harbour circulation patterns or pollution risk under Basslink operating regimes for the John Butters and Gordon power stations. Strong summer Gordon River flows which are beneficial for the aquaculture industry are maintained under Basslink. As a consequence, Basslink poses no issues for the aquaculture industry.

7.4 Hydro Tasmania Basslink Commitments

Hydro Tasmania is committed to implementation of the following mitigation measures if the Basslink project is approved:

- Maintenance of a minimum environmental flow in the Gordon River of 19 m^3/s between December-May, and 38 m^3/s between June-November, measured just upstream of the Denison River. Minimum flow targets will be lowered proportionately if inflows to Lake Gordon are lower, because the flow targets of 19 and 38 m^3/s are based on average pre-dam minimum flows, and the river under pre-dam conditions would experience flows lower than these during dry years. This minimum flow will be phased in over a period of years, to allow adequate monitoring of environmental benefit and understanding of environmental response to progressively increasing minimum environmental flows. A minimum environmental flow will improve conditions for the instream macroinvertebrate biota, by ensuring watering of the ‘mid-tidal’ zone and inundation of marginal snag habitats. It would also result in increased habitat for fish, improved food supply (macroinvertebrates) for fish and platypus, and be beneficial for the fluvial geomorphology by lessening scour of the bank toe and reduce phreatic surface gradient out of the banks. This measure is costed at $1.2 million in losses per annum to Hydro Tasmania.

- Implementation of a mitigation measure to minimise seepage-induced erosion of the Middle Gordon riverbanks, such as a ramp-down or step-down rule for the Gordon Power Station. An example of a potential power station operating rule which is receiving close consideration is the ‘210-150’ rule, which requires the power station to step down from discharges greater than 210 m^3/s to 150 m^3/s for one hour before shutting down, with the aim of allowing drainage of the upper portion of the bank and reducing draw-down rates. Hydro Tasmania is committed to an experimental approach to development of a mitigation measure that is both environmentally and economically sustainable. To support this assessment, Hydro Tasmania is committed to installation of robust long-term piezometer sites and development of a riverbank saturation-phreatic surface gradient model to test seepage response to different scenarios.

- Construction of a 1.5 Mm^3 capacity re-regulation weir to create an environmental control pond downstream of the Poatina tailrace. This pond would dampen 60% of the downstream flow fluctuations, and maintain a higher minimum water level in the weir ponds, thus improving present and Basslink environmental concerns with water quality fluctuations, bank erosion, stresses on instream biota, and problems for landowners with pumping arrangements and stock stranding. The environmental control pond is intended to be operational at the time of commencement of Basslink operations. This measure is costed at $400,000 per annum on an annualised basis.

Because of the absence of significant management issues, no mitigation options in relation to Basslink are required for downstream of the John Butters Power Station.

Hydro Tasmania is committed to review of the effectiveness of these mitigation measures, and future trends in environmental parameters in the Basslink-affected rivers, via a substantial Basslink monitoring program. This program would be additional to Hydro Tasmania’s existing Waterway Health Monitoring Program. The Basslink program is focussed on the waterways downstream of the Gordon, Poatina and John Butters power stations, and is costed at $333,000 per annum. The Basslink monitoring program commences three years prior to the Basslink development, with the first year being the 2000 investigation year, and goes for up to six years post-Basslink development.

Water management commitments can be incorporated into the Hydro Tasmania Water Licence and so be regulated under the Tasmanian *Water Management Act* 1999.

Regardless of the Basslink development occurring or not occurring, Hydro Tasmania is committed to compliance with its Aquatic Environmental Policy and ongoing implementation of its existing Aquatic Environment Program. This program includes major initiatives such as the Water Management Reviews and also a long-term Waterway Health Monitoring Program. Specific initiatives already occurring under the Aquatic Environment Program are continued assessment of the Gordon meromictic lakes, and evaluation of the Poatina Power Station flood rules.

7.5 Assessment of Overall Impacts of Basslink on Hydro Tasmania Freshwater Resources After Allowing for Mitigation Measures

From these investigations, a significant understanding has been gained of the present and the projected Basslink impacts of Hydro Tasmania water management practices on the ecosystems downstream of the Gordon, Poatina and John Butters power stations.

The majority of investigative effort was directed to the Middle Gordon River, as the existing impact of power station operations was quite unknown. Environmental issues downstream of the Poatina Power Station were able to be anticipated because of ongoing consultation and monitoring information, assisted considerably by the concurrent Hydro Tasmania Water Management Review in the Great Lake – South Esk catchment areas. Considerable information already existed on the existing environmental status and significant processes in the King River and Macquarie Harbour, from the King River – Macquarie Harbour Environmental Study in the early 1990s and the Mount Lyell Remediation Research and Demonstration Program in the mid-1990s.

The focus of the investigations has been on the environmental implications of changes from the existing flow regime to a Basslink flow regime. The three river systems under consideration are all substantially modified by existing flow regulation, and also by surrounding land use practices in the case of downstream Poatina and John Butters power stations. All of these river systems are accepted as ‘modified ecosystems’ through the Tasmanian State Government’s process of setting Protected Environmental Values. Investigations have required an understanding of the currently dominant processes and trends affecting the river ecosystems, and then projections of dominant Basslink processes and trends.

The extent of the investigations undertaken for this project is considered sufficient for assessment of the environmental implications of the Basslink project. These investigations have achieved their aim of providing very good insights into the present state of the rivers under consideration, and in identifying the types and extent of changes to the present conditions that could be anticipated to occur with Basslink changes. This information is considered sufficient to assess the impact of Basslink on the TWWHA, and to identify the most beneficial mitigation measures to accompany the Basslink development. Additional information over time is unlikely to change these conclusions, but rather allow refinement of theories and more precise quantification of spatial and temporal variability, processes and rates. Hydro Tasmania is committed to continuing to collect this information and if necessary refine its management practices to improve downstream environmental condition.

The assessment of World Heritage Area (WHA) values assessed four natural and three cultural TWWHA criterion, and concluded that the projected Basslink changes (in the absence of mitigation measures) has implications for two natural criteria. These criteria refer to features in the Middle Gordon River that are influenced by both present and Basslink operating regimes for the Gordon Power Station (riverbanks and riparian vegetation). Given that these features are not unique and are well-represented throughout the TWWHA, the assessment concluded that the influence of the Gordon Power Station does not substantially impact on the overall integrity of the TWWHA. Basslink in fact offers the potential for implementation of substantial river rehabilitation measures, which is in keeping with Australia’s commitments to restoration of WHA values wherever possible.

The Basslink project accompanied by the Hydro Tasmania commitments presents an opportunity to improve environmental management and sustainability of the Tasmanian freshwater resources, because it provides the financial framework for Hydro Tasmania to implement major riverine enhancement measures for the Gordon River and downstream Poatina Power Station. Whilst by definition “natural” conditions can never be achieved in a regulated river system, these measures represent the best practicable approach to improving environmental issues of concern, both present and Basslink issues, in the respective waterways.

The effectiveness of these measures will be closely documented through a substantial Basslink monitoring program which in itself is a major benefit of Basslink. Hydro Tasmania is committed to an adaptive management approach in responding to information obtained through the monitoring program, so that mitigation measures can be re-assessed and fine-tuned over time to ensure that they are environmentally and economically sustainable.

7.6 Conclusions

A major program of environmental investigation has been undertaken into the potential impacts of the Basslink development on Tasmanian waterways. Only three river systems (Gordon, King, and Brumbys Creek and downstream of this creek) and one estuarine system (Macquarie Harbour) are predicted to experience changes in hydrological regimes. These are already modified ecosystems which have experienced alterations due to the regulated flow regimes and other human impacts. The Basslink changes to Hydro Tasmania power station operations are projected to cause further alterations to key environmental parameters in the Gordon River and downstream Poatina in the absence of any mitigation measures.

To address these projected impacts, Hydro Tasmania is committed to major riverine enhancement measures and a substantial monitoring program to accompany the Basslink development. These include a minimum environmental flow in the Gordon River, implementation of a mitigation measure to minimise seepage-induced erosion of the Middle Gordon riverbanks, such as a ramp-down or step-down rule for the Gordon Power Station, and construction of a 1.5 Mm^3 re-regulation weir downstream of the Poatina Power Station. These measures accompanied by a major monitoring program represent a very substantial commitment by Hydro Tasmania to sound environmental practices with their operations, costing at least $2 million per year.

In conclusion, the Basslink project accompanied by the Hydro Tasmania commitments presents an opportunity to improve environmental management and sustainability of the Tasmanian freshwater resources, because it provides the financial framework for Hydro Tasmania to implement major riverine enhancement measures for the Gordon River and downstream Poatina Power Station. The proposed mitigative measures are in keeping with Hydro Tasmania's environmental policy and growing list of environmental achievements. They further demonstrate Hydro Tasmania's commitment to the sustainable management of Tasmania's water resources.

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