



WEST VICTORIA RFA WATER FORUM

A Water Forum to discuss issues relating to water and forest management was held in Geelong on Wednesday 1 December 1999.

During public meetings held in August 1999, to discuss the West Regional Forest Agreement (RFA) process and the Comprehensive Regional Assessment (CRA) report, issues and concerns about water quality and quantity in regard to forest management were raised. The Water Forum was held in response to requests to discuss the issues.

The Forum provided the opportunity for stakeholders to get a better understanding of the issues, and to assist the Victorian and Commonwealth Governments in the RFA decision making process. The contributions made by those who attended the Forum is appreciated.

The proceedings of the Forum are documented in the attached report written by Michael Williams, an independent consultant from Michael Williams & Associates. The report contains views from the many people who attended the Water Forum. Views expressed are not necessarily those of the Victorian RFA Steering Committee or the Commonwealth or Victorian Governments.

Dougal Morrison
Director
Victorian RFA Team

16 February 2000

Proceeding of a Water Forum – West Victoria Regional Forest Agreement

Wednesday 1 December 1999 - Geelong Victoria

A report prepared for the Joint Commonwealth/Victorian Regional
Forest Agreement Steering Committee

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Report prepared by

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Water Forum – West Victoria Regional Forest Agreement

Wednesday 1 December 1999

Executive Summary

The capacity of native forests to provide the quantity and quality of water expected by the community, particularly in the Otway region of Victoria, was a key concern raised during the consultation period following the release of the West Victoria Comprehensive Regional Assessment. A forum to address this concern and increase understanding of the issues involved was held in Geelong on 1 December 1999. The objectives of the forum were to:

- increase understanding of the complexities of water quality and quantity issues in relation to forest management;
- share the knowledge of the scientific community about water quality and quantity research in relation to forest management;
- provide insight into the differing points of view in relation to these water and forest issues so that involvement in the Regional Forest Agreement (RFA) process reflects these greater understandings and insights;
- discuss stakeholder and community concerns regarding water quality and water quantity in relation to forest management; and
- ensure that Commonwealth and Victorian RFA officials are fully informed of the range of community views as they continue to develop the West Victoria Regional Forest Agreement.

Seven speakers, including researchers, managers and community group representatives presented their work on a range of topics at the forum.

- Pat O’Shaughnessy – a consultant in forest management specialising in water issues, addressed the regulation of forest and water issues in Victoria, including an historical review of research. He noted that codes of practice are an important aspect of regulating forest industries and that there is a need to widen the jurisdictions and application of codes of practice to include private as well as public land. He also explained that road crossings of streams are a significant source of sediment into catchments and need to be better managed.
- Tim Fletcher – a water resources manager for the Corangamite Catchment Management Authority, spoke on local catchments, stream indexing, multiple use and the impacts on water. He noted that there are varying values placed on water and waterways by communities and that a range of impacts affect land and waterways in catchments. He indicated that while there is a need for long-term environmental monitoring, the streams in forested catchments in the Otways provide excellent water quality. The key components of monitoring stream condition are:
 - hydrology;
 - physical form;
 - riparian zone;
 - water quality; and
 - aquatic life.

- Chris Tipler from the Otway Ranges Environmental Network, spoke on water yield in the Otways. He emphasised that when the value of timber harvested in the Otways is compared to the value of water that is lost due to timber harvesting, there is no sound economic argument to support the continuation of logging in the Otways.
- Loris Duclos from the Wombat Forest Society, addressed ground water issues in the Midlands Forest Management Area. She raised concerns about selective application of scientific literature to support particular positions and she spoke on the care that needs to be taken in applying generic forest management rules at a local scale. The need for greater depth of knowledge in making decisions, especially such land use decisions as the West Victoria Regional Forest Agreement or the location of pine plantations, was stressed.
- Jacky Croke - a senior research scientist with CSIRO, spoke on forest operations and water quality. She discussed the need for continual improvement in best management practices to assist in the effective management of forests, as well as the need to re-evaluate the range of questions asked by scientists studying catchment processes and management. Jacky explained that sediment from roads is the major contributor to stream sedimentation during timber harvesting, with channelled flow the key sediment transportation mechanism.
- Rob Vertessy - the program leader in the Co-operative Research Centre for Catchment Hydrology, addressed forest operation and water yield, focussing on the effect of logging on stream flow. The decline in stream flow when old growth forests are replaced by regenerating forests, Rob said, can be largely explained by the change in forest structure and growth rates. It is also related to climate and soil depth. He noted that the reduction in stream flow in pine plantations is greater than in native forests and that the peak reduction in stream flow occurs within a few years after logging.
- Kylie White from the Victorian Department of Natural Resources and Environment, spoke on forest management planning processes, explaining the range of regulatory and prescriptive codes applying to the timber industry.

The Forum concluded with a summing up by the facilitator Michael Williams who stressed the need to recognise that forest management involves a complex suite of issues and that the values ascribed to forests are often based on personal values. As community values range across a broad spectrum, there is benefit in involving scientists, the community and policy makers in the debate. Forest management is about reconciling the different uses and values placed on those uses by the community.

Water Forum – West Victoria Regional Forest Agreement

Wednesday 1 December 1999

Agenda

Strachan Room, National Wool Museum, Geelong

10:00-10:10am

- Introduction by Michael Williams (Environmental facilitator - Michael Williams & Associates Pty Ltd – Sydney)

10:10-11:00am Overview of Victoria and local region

- Pat O’Shaughnessy (Pat O’Shaughnessy and Associates) - historical review of research, and the regulation of forest and water issues in Victoria
- Tim Fletcher (Research Scientist) - local catchments, stream indexing, multiple use and the impacts on water

11:00-11:20am Morning tea

11:20 - 12:10pm Community Issues

- Chris Tipler (Otway Ranges Environment Network) - Water yield - implications of the evidence
- Loris Duclos (Wombat Forest Society) - Midlands ground water issues

12:10-1:00pm Lunch

1:00-2:15pm Current Research and Practises

- Jacky Croke (CSIRO and CRC for Catchment Hydrology) -forestry operations and water quality
- Rob Vertessy (CSIRO and CRC for Catchment Hydrology) -forestry operations and water yield
- Kylie White (Department of Natural Resources and Environment) - forest management planning processes including Forest Management Plans; Code of Forest Practices for Timber Production

2:15-2:30pm Break

2:30- 3:45pm Discussion, questions and sum up by Michael Williams

Introduction

Introduction – Michael Williams - Independent facilitator (Michael Williams & Associates Pty Ltd - Environmental facilitators and consultants – Sydney)

Welcomed the speakers and audience to the West Victoria Regional Forest Agreement (RFA) Water Forum and provided a context for the Water Forum. He explained that:

- one of the key issues raised during public meetings for the release of the Comprehensive Regional Assessment (CRA) for the West Victoria RFA and particularly the Otways was the perceived affect native forest harvesting has on the quantity and quality of water from those catchments; and
- the water forum is a response to the concerns raised by the community at these public meetings and recognises the complexity of the debate about water quality and quantity in relation to forest management.

Outlined that the forum is intended to:

- increase our shared understanding of the complexities of water quality and quantity issues in relation to forest management;
- share the knowledge of the scientific community about water quality and quantity research in relation to forest management
- gain greater insight into the differing points of view in relation to these water issues so the development of the RFA reflects these greater understandings and insights
- discuss stakeholder and community concerns regarding water quality and water quantity in relation to forest management
- participate in the debate so that the RFA project teams from the Commonwealth and Victorian Governments are fully informed of the range of community views as they continue to develop the West Victoria RFA

Explained that:

- there is a great variety of community and stakeholder groups with an interest in forest management and water who have been invited to this Water Forum;
- the Water Forum includes opportunities for those present to ask questions of the speakers about their particular interests, and challenge and clarify the information and views of the speakers; and
- most importantly, the Water Forum provides an opportunity to share information in a courteous manner.

Water Forum 1 December 1999

Regulation of Forests and Water Issues in Victoria

by Pat O'Shaughnessy (*Pat O'Shaughnessy and Associates*)

Background on Pat O'Shaughnessy

Pat O'Shaughnessy is a graduate of Melbourne University and the Australian Forestry School. After a period in Tasmania he spent 25 years with Melbourne Water in charge of a major catchment hydrology research program and also contributed to several important environmental impact statements. Pat is a past Chairperson of the Forest Hydrology Working Group of the Australian Forestry Council. Since 1993 Pat has been working as a consultant in forest management specialising in water issues and is currently a member of the West Gippsland Catchment Management Authority. He is the author of numerous papers/reports dealing with catchment hydrology and associated issues.

Summary Points

- A undisturbed forest, especially mountain ash forest, provides water of high quality.
- Victorian research into mountain ash forest/water interactions has been undertaken since the early 1970s. The initial thrust was undertaken by the Melbourne and Metropolitan Board of Works and in recent years has been undertaken by Melbourne Water and the Co-operative Research Centre for Catchment Hydrology.
- Well supervised and implemented Codes of Forest Practice and Management Plans are essential in bringing about good practice in terms of water quality and quantity.
- Proper implementation of Codes of Forest Practice and their specific requirements require a total commitment by all those involved in forest harvesting and regeneration operations.
- Unmanaged road drainage at stream crossings provides a threat to water quality.
- Water quality on a harvested coupe can be protected by the appropriate drainage of snig tracks, the adoption of buffer strips and the prohibition of logging during rain. For cooler winter rainfall sites winter logging should be avoided. Where possible uphill snigging should be adopted.
- Buffer widths along streams should vary in their width according to soil types and slope. The wetted zone of a stream should not form part of the buffer strip.
- For mountain ash forest on deep soil types long rotations can increase water yield.

Pat O'Shaughnessy - Points of Clarification
Regulation of forest and water issues in Victoria

Clarification

Query relating to slide showing water yield and the impact of clearfelling? (Chris Tipler)

Response

Confirmation that the slide showed that water yield impact is greatest three to four years after clearfelling has taken place

Clarification

What is growth rate of water use in Melbourne? (unidentified)

Response

Estimated around 2% per annum – this rate has decreased because of increased home unit developments that do not have gardens requiring water etc.

Clarification

Seeking confirmation that the graph in the presentation showed that sediment movement is greatest off roads? (unidentified)

Response

Confirmation given that this was the case.

Clarification

Relating to experimental pattern of clearing, thinning etc. shown in one of the slides – question asked about whether this pattern of different treatments could be used in the Otways? (unidentified)

Response

Reply given that the same treatments may not be applicable because Otways area is generally too steep and experimental pattern in the same manner as the Melbourne Water experiments may not be possible, however, this response was given with caveats about the need to develop treatments that were specific to an area and that were within the Code of Forest Practices for Timber Production.

Clarification

Query regarding graph showing water yield rates and whether a relationship existed between clearfelling and low water yields? (Loris Duclos)

Response

In catchments experiencing lower than average rainfall and therefore low soil moisture, as is the case for the Otways at present, the impact on water yield was more affected by the lower than normal rainfall than forestry operations.

Dr. Tim Fletcher

Tim Fletcher completed his PhD at the University of Melbourne, analysing and predicting the long-term impacts on rivers from land and water use. Tim has worked both as a scientist and a practitioner, and is now the Water Resources Manager for the Corangamite Catchment Management Authority. Prior to that, he was a Senior Environmental Scientist with Melbourne Water, develop guidelines to protect waterways from the impacts of urban stormwater. Tim also worked with Central Highlands Water, involved in both environmental and water supply planning roles.

Tim recently co-ordinated the most comprehensive assessment of river condition undertaken in the region – the Index of Stream Condition. He continues to have a strong research involvement, supervising postgraduate students at both Deakin and Ballarat Universities, in the area of waterway health.

Summary of Presentation

Introduction

- General presentation - sets the context for more specific presentations which follow
- The information presented is not “new”
- it is a broad summary of our state of knowledge of local waterways
- Presents the big picture of waterways in the region - both the condition & impacts

Outline

- Outline of regional waterways
- Values of waterways
- Impacts on waterways
- Condition of waterways
- Methods to protect waterway values

Waterways within the West RFA

- Covers part of 16 river basins
- Goulburn Campaspe Loddon Avoca
- Yarra Maribyrnong Werribee Wimmera-Avon
- Moorabool Barwon Otway Coast Lake Corangamite
- Hopkins Portland Coast Glenelg Millicent
- Waterways in the South West
(Barwon, Moorabool, Corangamite & Otway Coast Basins)

Waterway Values & Uses

- Environmental
- Economic - incl water use
- Social
- provide detail

Impacts on Waterways

- Urbanisation
- Impacts on Waterways
- Agriculture (incl. grazing & cropping)
- Impacts on Waterways
- Forest Harvesting

Scales - Spatial & Temporal

Condition of Waterways in SW Vic

- Two comprehensive assessments of environmental condition:
- Mitchell (1990)
- 96 sites
- Index of Stream Condition (ISC) (1999)
- 217 sites
- Condition Assessment - Mitchell
- 10 factors important to aquatic organisms
- bed composition, pools & riffles
- bank & verge vegetation
- cover for fish (snags, boulders, undercut banks)
- flow depth & velocity
- submerged vegetation, instream organic matter
- sedimentation or erosion
- Environmental rating
- very poor - poor - moderate - good - excellent
- Condition Assessment - ISC
- Hydrology
- deviation from natural flows
- Physical form
- bed & bank stability
- barriers to fish passage
- instream habitat (snags, etc)
- Streamside zone
- vegetation cover & condition, weeds, regeneration
- Water quality
- total phosphorus, turbidity, EC, pH
- Aquatic life
- macroinvertebrate population diversity
- Results - Mitchell & ISC
- Excellent condition
- Medium condition
- Very poor condition

Why protect our waterways?

How should we protect waterways?

- Context set - lots of uses, values
- How then, within that context
- Best practice
- Long-term monitoring & review - watch for cumulative effects

Tim Fletcher - Points of Clarification

Local catchments, stream indexing, multiple use and the impacts on water

Clarification

Query regarding water quality data presented for the Barwon River showing that the River was rated as being in excellent health? Given a landslide occurred in July 1999, how can this still result in an 'excellent health' rating? (Simon Birrell)

Response

This was a site specific event that did not affect the river as a whole. Index of Stream Condition uses several points for measurement along the river and measures a range of different parameters.

Clarification

Does water quality generally decrease as you move through different land uses? (unidentified)

Response

In general, yes, it is the case with the 'best' water quality in the forest and this declining as it moves through agriculture to urban and then to industrial areas.

Clarification

Does the Code of Forest Practices for Timber Production satisfy best management practice? (unidentified)

Response

Unable to comment but suffice to say that there is a requirement to develop best management practice for crown lands. Codes of practice need to be constantly updated as new science and information comes to light.

Address by Christopher Tipler of
The Otway Ranges Environment Network
To the Western RFA Water Forum

Wednesday December 1, 1999

Summary of Key Points

- Water is the most precious resource in South West Victoria. It will be increasingly in short supply and will become expensive.
- The Otway Ranges are the principal source of water for South West Victoria, extending from Geelong to Warrnambool. The nine catchments in the Otways, which account for almost half of the State Forest, supply water to over 250,000 people.
- Our native forests are a truly wonderful natural reservoir that enable us to avoid the need to invest in man-made reservoirs.
- The forest catchments in the Otways (and other parts of Western Victoria) are being heavily logged, mainly by clearfelling.
- The value of woodchips and timber harvested from Otway catchments has a market value of less than \$8 million p.a., yet the value of water lost as a result of logging has a market value of around \$25 million p.a. (based on mid-range assessments).
- Even if very low water losses are assumed, the economics still clearly favour water over logging.
- Melbourne's water comes from protected catchments.
- The community in South West Victoria has indicated quite clearly that it does not want its water catchments logged.
- To allow logging in water catchments is stupid. It is an embarrassing failure of public policy.

Chris Tipler - Points of Clarification

Water yield - implications of the evidence

Clarification

Query relating to cost analysis of water and whether the costs of discharging water once it has been used had been factored into the economic comparison? (Steve Roffey)

Response

The value analysis presented was “very crude” so the full costs of water had not been taken into account – this is something that will be attempted in the future.

Clarification

A statement that the analysis is flawed because it does not compare like with like. The value of water out of the tap is not being compared with the value of timber in the shop, for example, in the form of a piece of furniture. The analysis presented does not consider positive flow-on effects. (Jon Drohan)

Response

There are no timber processing industries in the region, otherwise they would have been factored into the analysis. Old employment multipliers no longer relevant or valid. Woodchips are the main product coming out of the forest and these do not have positive flow-on effects in the region.

Comment

Jon Drohan responded that the analysis had not considered the “joint production function” and that both water and timber could both be produced without adversely affecting each other.

Clarification

Query about whether forestry management really has an impact upon water yield or is water yield controlled more by the prevailing climate? (Claire Miller)

Response

Unsure, but felt that precautionary principle should be adopted and that logging for just \$7.6 million of woodchips, which is a small part of the regional economy, did not make any financial or environmental sense when compared with the \$25 million value of the water lost due to logging.

Geelong Water Forum

Wednesday December 1st 1999, 10am-3:45pm

National Wool Museum, 26 Moorabool St, Geelong

Speaker: Loris Duclos (community representative)

Personal Introduction

Following several years of involvement with many different community, school, sporting and other groups, I first became involved with community land use and environment issues about a decade ago. This led me to commence tertiary studies in Natural Resource Management at the School of Mines in Ballarat in 1993, winning the Award of Excellence for that year. Since that time I have conducted part time study at both SMB and more recently at Forestech near Lakes Entrance. Unfortunately formal studies have had to come second to my family responsibilities and my deep commitment to strengthening local community understanding and involvement in land use issues.

(1989-91) Founding member Friends of Cockatoo Creek, (1993-94) Friends of the Earth, Project Officer Melbourne Water Sewerage Strategy Review, (1994-ongoing) Wombat Forest Society Water Researcher, (1995-96) Victorian Environment Defenders Office Board member, (1997) Daylesford Water Quality Community Group, (1998-ongoing) Tambo Environment Awareness Group RFA Project Officer, (1999) Consultant to the Australian Conservation Foundation RFA Working Group.

Background

Many people from Geelong and the West RFA region have raised 'water' as the key issue to be addressed during the RFA process and a major consideration for ongoing forest management. This should come as no surprise to anyone given the ever-increasing pressure being placed on the limited water resources in the region.

Today we have the cream of forest hydrology researchers together under one roof and the community will be given the opportunity to hear the latest in forest research. We will also hear about forest management and how this has evolved to the current management systems that we see today.

It is my intention to discuss some of the weaknesses and failings with contemporary forest science and the forest management systems discussed by the other speakers. Focusing on soil and water issues that obviously concern this community I hope to stimulate discussion around the appropriateness and effectiveness of forest sciences and management on the ground, in this region.

West Victorian Rainfall and Drainage Issues

West Victoria is much drier than the East of the State and the population pressures on the highly fragmented island of forest are much greater.

Forest Hydrology Research and its application in West Victoria

Historically forest hydrology research in Victoria has been focused on the Ash type forests in the Melbourne Water, water supply catchments. The results suggest that following logging or wildfire an initial increase in runoff is expected over the first few years, then runoff reduces as regrowth establishes. Substantial reductions in streamflow have been observed and this reduction persists for a long period of time.

This research is relevant to the Ash type forests that are located in the water supply catchment in the Otways FMA. Many of the regions serviced from the Otways catchments are experiencing water shortages. It is most unfortunate that the hydrology studies in the Otways have been abandoned due to lack of funding and lack of political will.

Mixed species forests are not so well understood, only very limited research has been conducted in these forest types. Based on a small experimental area and limited research, the MW Catchment Hydrology Team concluded that there was little or no impact on streamflow from wildfire in the drier mixed species forest.

The NRE Forest Planning process and institutional biases

The State Forestry Agency has in place a system of managing our forest which is supposed to include measures to protect soil and water values. There is much evidence that forest planners are focused most strongly on timber production and other important environmental considerations are paid cursory lip service only.

The Forest Management Plan Process has failed to deliver community confidence or industry security. Portland still does not have a Forest Management Plan. The Code of Forest Practices for Timber Production Revision 2 watered down the recommendations for soil and water protection and is often poorly implemented on the ground.

Loris Duclos - Points of Clarification Midlands groundwater issues

Clarification

Statement made that the material presented on groundwater and mineral springs was equivocal and that most of the groundwater recharge to the mineral springs was most likely occurring through basalt aquifers. (Phil Dyson)

Response

Rejected by speaker who stated that research undertaken had shown that the recharge areas for the mineral springs were as shown on the slide and mostly around the mineral springs themselves.

Clarification

Query about whether the research work undertaken in the Wombat Forest had gone through peer review and also a comment stating that new pine plantations were not necessarily environmentally inappropriate because they require a code of practice whereas agriculture is not required to abide by a code. (Chris Dare)

Response

The location of pine plantations is the key because much of the region is open grassy woodlands that would not, under natural conditions, support pine plantations which are much taller and denser than an open grassy woodland. The Vision 2020 document's pine plantation targets for the region are out of step with the natural regimes and that the introduction of new pine plantations could adversely affect water yield and the natural ecosystem functioning of the region.

Clarification

Statement made about when clearfelling as a forestry management technique started. Questioned the logic of how forest harvesting can be held responsible for problems when the Wombat Forest always had low water yields? (Jon Drohan) **Response**

Taken as a statement

Water Forum Geelong Dec 1st 1999

Background of Speaker- Dr Jacky Croke

Dr Croke is a Senior Research Scientist at CSIRO Land and Water based in Canberra. She joined the Cooperative Research Centre for Catchment Hydrology in March 1995 as Project Leader of the Sediment Movement in Forests project within the Forest Hydrology Program, led by Dr Rob Vertessy. Her major areas of scientific expertise lie in processes of sediment movement and delivery, and catchment response to major land use disturbances. Together with the project team, Dr Croke has written journal papers, reports and reviews on the subject of sediment movement in forests and has recently summarised the project's findings in an industry report entitled 'Managing sediment sources and movement in forests: the forest industry and water quality. The project findings have already been incorporated into recommendations for the NSW Pollution Control Licence and reviews on Codes of Forest Practices.

Presentation Summary

- **Introduction**

Defining water quality and outlining problems and inherent limitations of previous scientific approaches. Purpose of this presentation is to outline some of the key principles and processes involved in forest activities and water quality protection. The aim is not to address questions relevant to specific catchments but to outline the principles that can then be applied elsewhere.

- **What water pollution actually requires and entails**

In order for water pollution to occur within any catchment, you need three key ingredients;

- a source or multiple sources of sediment
- a sediment delivery pathway which transports this material to the stream network
- ineffectiveness or failure of current Best Management Practices

Water pollution represents the product of both sediment generation **and** delivery

- **What do we know about sediment generation, sediment delivery pathways and the effectiveness of Best Management Practices?**

We must open up the **black box** in scientific research and come up with much clearer understanding of the processes and principles underlying forest activities and water quality. Key questions include;

What are the major sources of sediment and associated pollutants
What are the key pathways that deliver this material to the stream network
How effective are BMPs and how can they be improved.

- **What can we say about the impact of logging activities and water quality after 30 years of research?**

Brief summary of key findings in the international literature relating to the issue of forestry and water quality. There are certain things that appear well-established in the literature and certain things that remain very speculative. What are these and what are the implications for how we address the issue of forestry and water quality

- **The way forward- challenges for the logging industry**

Can science change community perception on logging and water quality?
What can the industry do to ensure best management practices are adhered to and regularly updated?

Jacky Croke - Points of Clarification Forestry operations and water quality

Clarification

In what months were the experimental works conducted? (John Endacott)

Response

December in New South Wales and October in East Gippsland.

Clarification

- What about un-seasonal rainfall events? (John Endacott)

Response

Three rainfall intensities were used in the research. This would account for the intensity of un-seasonal rainfall events.

Clarification

- Is road maintenance an issue for sediment movement? (Kersten Gentle)

Response

Road maintenance is a real issue because what tends to happen is that road drains and runoff channels are maintained to be as neat and tidy as possible thereby reducing the roughness of these drains when this actually reduces their effectiveness as a sediment trap. The Code of Forest Practices for Timber Production has the right intention but it is in the implementation and monitoring stages that sometimes encounter problems.

Clarification

- Query regarding whether clear felled areas cause more sediment runoff than other areas within the coupe? (Matt Armstrong)

Response

It all depends on how much overland flow is being generated by the particular areas within the coupe. In some cases clear felled areas can retain sediment through infiltration and trap sediment as they can have quite rough surfaces - the key is the degree of soil compaction and how rough the surface is and therefore its ability to trap sediment.

The Impacts of Forestry on Catchment Runoff

Dr Rob Vertessy

CRC for Catchment Hydrology, CSIRO Land and Water, Canberra

Personal Introduction

Since 1987, I have been a research scientist at CSIRO Land and Water, and a Program Leader in the CRC for Catchment Hydrology (CRCCH) since its beginning in 1992. Between 1995 and 1999 I led the Forest Hydrology Program in the CRCCH, and am now leading the new Predicting Catchment Behaviour Program. My personal research is focussed on forest and plantation water use and the simulation of catchment runoff using process-based hydrological models. I lead the Forests and Water Task Force on behalf of the International Union of Forest Research Organisations (IUFRO).

Scope of my presentation

- Differences in runoff between grassed and forested catchments
- Changes in mean annual streamflow after forest disturbance
- The effects of forest age on streamflows
- Changes in peak and low flows after forest disturbance
- The water yield impacts of afforestation of agricultural land

My main points

Well established generalisations

- Pine runoff < Eucalypt runoff < Grassland runoff; differences are amplified with increasing rainfall
- Afforestation reduces low AND high flows as well as mean runoff
- Streamflow changes linearly with % forest area cleared or planted
- Following clearing, peak changes usually occur within 2-3 years; recovery usually takes 4-10 years but may take as long as 25 years

Generalisations supported by limited evidence

- Forest age affects ET rates in moist eucalypt forest; old growth stands yield more runoff than stands aged 20-30 years
- Afforestation of grasslands reduces low flows proportionally more than median and high flows
- Forest thinning has similar impacts as patch cutting in terms of magnitude of response, provided a similar basal area is treated
- Effects of patch cutting are felt longer than for thinning

Still speculating but confident

- Forest age affects ET rates in dry eucalypt forest; there is little hydrometric data to substantiate this
- Transpiration per unit leaf area declines with forest age; two good case studies of this exist but require confirmation in other forest areas

Rob Vertessy - Points of Clarification
The impacts of forestry on catchment runoff

Clarification

- Do fast growing species take up water and dry out the soil profile? (Carol Wilmink)

Response

Confirmed

Clarification

- What are the trade-offs - should you just leave the old-growth forest and then have pine plantations in other appropriate locations? (Claire Miller)

Response

Retain as much old growth as possible and then plant pine plantations – from a catchment management and water yield point of view this can be appropriate.

Clarification

- Is water above the Kuczera curve “lost”? (Cameron Steele)

Response

Yes, is sometimes described as “lost”.

Clarification

- Are modest intensity forestry operations in native forests better than establishment of pine plantations in terms of water yield? (Geoff Proctor)

Response

The effects of forestry operations on water yield are reduced as you move from higher rainfall to lower rainfall areas. As a well established generalisation pine plantation runoff is less than native forest runoff.

Clarification

- What is your definition of old growth forest? (Belinda Murnane)

Response

Around 200 years plus.

Summary of Presentation by Kylie White, Victorian Department of Natural Resources and Environment

Forest Management for water yield and quality

- Department of Natural Resources and Environment
- Code of Forest Practices
- Otway Forest Management Plan
- Midlands Forest Management Plan

Code of Forest Practices

- Provides Statewide goals and guidelines that apply to:
 - timber harvesting
 - roading
 - regeneration
 activities
- Objectives and principles established
- Basis for more detailed plans and prescriptions
- Developed with advice from CSIRO

Code - water supply catchments

- Stream buffers and filter strips
 - Soil type and slope are considered in applying buffers and filters
- Limitations on harvesting steep slopes
- Rotation lengths that minimise yield impacts in water catchments
- Limitations on areas harvested annually in water supply catchments
- Road design and construction standards

Midlands Forest Management Plan

- Designated catchments established
 - important catchments for domestic water supply
 - additional prescriptions established to add to security of water supply
 - winter closures
 - coupe size limits
 - limit on area of regrowth in catchments
 - limit on annual harvest area

Otway Forest Management Plan

- Water supply catchments assessed
 - Sensitivity to disturbance or yield decline
- Additional prescriptions established
 - Winter harvesting suspension
 - Limits on annual area harvested
 - Limit on 10 year area harvested
 - Slope limitations and wider buffers on high land degradation hazard sites
 - Total closure of highly sensitive catchments

Kylie White - Points of Clarification

Department of Natural Resources and Environment - forest management planning processes

Clarification

- What are the legal requirements in relation to the application of the Code of Forest Practices for Timber Production and what happens when the Code is breached? (Svea Pitman)

Response

All logging operators are subject to the Code of Forest Practices for Timber Production for each coupe. In those cases where a breach of the code is identified, penalty points accrue to the operator - like a system of demerit points.

Clarification

- How does one get to see coupe plans that detail the proposed actions to be undertaken and agreements made? (Svea Pitman)

Response

Coupe plans can be made available for the public to view.

Clarification

- How are the Forest Management Plans developed (Kersten Gentle)

Response

Forest Management Plans are developed with the community and have a number of stakeholders involved in their preparation.

Question and Answer Panel Session

The panel was comprised of all the speakers. Phil Dyson a specialist in groundwater also joined the panel.

- **Question - Rod Anderson.**

- Concerned that all the speakers assume that logging will continue, forestry is only one possible use of the forest amongst many others. Concerned that Rob Vertessy has naively ignored the effect on water yield of forestry operations in native forests and especially establishment of pine plantations.

Answer - Rob Vertessy.

This is a complicated matrix of questions that cannot be reduced to a yes or no answer. Catchments are dynamic and stakeholders have different values about differing uses of the forests. It is important to set up protocols that reflect community values of the system as a whole. Within such protocols it would then be possible to weigh up the balance between retaining native forests or establishing plantations.

- **Question - Tim Anderson**

- The Wombat Forest is currently in it's second stage of harvesting and will be significantly logged by the year 2015 under the shelterwood system and leave the forest with young stands under 40 years old. Is this a 'proper' multiple use approach? Does this form of management have a negative impact on water yield?)

Answer - Rob Vertessy

Forests with a higher proportion of regenerating forest have a reduced water yield.

- **Question - Kersten Gentle**

- Stated that tourism generates \$500 million, and forestry generates \$53 million regionally. Given that these industries currently co-exist is it not better to have both the \$553 million coming into the economy from tourism as well as the \$53 million from forestry rather than just wiping out the \$53 million provided by forestry? Timber plus tourism equals growth and there is a presumption by many speakers that tourism plus timber cannot co-exist when they have been doing so for many years.

Answer - Chris Tipler

Tourist growth has mainly been along the coastal strips because the hinterland is seen as a logging area. The hinterland has great potential to increase tourism growth as long as clear felling of native forests was abandoned. Indeed, this approach is supported by the number of Councils in the region that are moving to prevent logging from taking place in their Council areas. Concerned about the loss of jobs, but believes that through structural adjustment programs displaced forestry workers could still be financially viable in the region but would need to move to different areas of employment. Forests are being exploited for the benefit of a small group of people.

Comment - Kersten Gentle

The forests are multiple use forests and timber production should be maintained, as well as the tourism industry.

Question - member of Geelong Field Naturalist Club

- How is it that clear felling is taking place in areas that appear to be contrary to the restrictions in the Code of Forest Practices?

Answer - Kylie White

The Code of Forest Practices is applied in every forest coupe and harvesting cannot generally proceed on slopes greater than 30 degrees. Soil erodability and erosion potential are taken into consideration according to the Code of Forest Practices.

Question - Svea Pitman

- Stated that there is an “obvious” impact on water quality and water quantity as a result of logging and asked the panel to confirm that logging does have a direct impact on water quality. Also asked in relation to Tim Fletcher's and Jacky Croke's presentations, if turbidity was also measured as a criteria of water quality?

Answer - Jacky Croke

Water quality was measured by turbidity. Measuring turbidity does not allow you to identify or “finger print” the source of the sediment and, as a result, you cannot say which particular logging area is definitely responsible for the turbidity in the catchment.

Answer - Tim Fletcher

Water quality is just one of the parameters in the index of stream condition. Although turbidity is used in the index of stream condition, a number of other parameters relating to water quality such as aquatic health and in-stream condition were also used. It is still not possible, however, to confidently assert that logging has a direct impact on water quality.

Question - Jon Drohan

- Given that strip thinning the forest and resowing the areas as paddock would maximise water yield, will this be considered as a forestry management technique.

Answer - Kylie White

It is unlikely that such an approach would be supported.

Answer - Rob Vertessy

It would optimise water yield but it has not been done anywhere else in the world.

Question - Carol Wilmink

- Questioned the health effects of having to chlorinate water due to turbidity? Cited a survey that shows that prostate cancer affects one in ten men in Australia, and that this increase has been traced to chlorination of the water. Asked if better water treatment processes still needed to use chlorine.

Answer - Tim Fletcher

- Chlorine is not used to treat turbidity as such. It is used to treat pathogens.

Answer - Loris Duclos

Noted that turbid water is flocculated with alum. The more turbid the water, the more alum required.

Comment - other members of the panel

Other members of the panel agreed that chlorine is used to treat pathogens not to treat turbid water.

Question - Claire Miller

- If roads are the main source of sediment, which are the “worst” type of roads as far as generating sediment is concerned, forest roads or tourism roads? If we had roads for tourism would we need as many as are required for forestry operations?

Answer - Jacky Croke

The source and amount of sediment is directly related to surrounding land use, intensity of traffic, type of traffic, soil conditions when trafficked and road maintenance. Many forest roads already exist and these older roads may not be located in the most appropriate locations. A road audit may be needed to identify which ones are no longer required. The key factor of how much sediment runs off a road is the density and frequency of traffic - the road does not distinguish who uses it.

▪ **Question - Gavan McFadzean**

- Have there been any studies that analyse the difference between water use between mixed species native forests and pine plantations?

Answer - Rob Vertessy

It is well documented that in terms of evapo-transpiration, pine plantations use more water than native plantations.

▪ **Question - Tom Fox**

- When a coupe is over 30 degrees, the Code of Forest Practices for Timber Production determines that it should not be logged. However, in recent conversations with a forest operator, it was revealed that the average slope of the whole coupe is used. This occurs despite that fact that there may be significant variations in slope of the coupe. Therefore clearfelling can take place on those parts of the coupe that may be in excess of 30 degree slope.

Answer - Kylie White

The Code of Forest Practices provides a slope limit of generally 30 degrees for logging coupes but forests officers may determine that logging can still go ahead if some small areas are above this 30 degree limit.

Comment - Tom Fox

If that is the case then the legislation is too lax - logging should not occur on slopes greater than 30 degrees slope.

Comment - Kylie White

If forest operators contravene the coupe plan, they accrue demerit points.

▪ **Question - Belinda Murnane**

- Water quality and water quantity issues have been around for decades. As a result there is a considerable amount of data available for the Otways that could have been used to make today's presentations much more informative.

Answer - Rob Vertessy

Acknowledges the CSIRO work presented at the forum was not done in the Otways region. However the research would not invalidate what has been presented by CSIRO because generic principles have been presented that can be applied across a range of forest locations including the Otways.

Comment - Belinda Murnane

The community has been dealing with water quality issues for over a 100 years and the issue of impact of forestry operations on water quality and quantity needs to be broadened beyond just looking at logging activities. The impacts of other land uses also need to be considered.

Comment - Loris Duclos

Catchment Management Authorities (CMA) look at land use impacts. Although CMAs have responsibilities for both private and public lands they do not have much influence on public land. Yet much of the activities on public land are contributing to water quality and water quantity impact. The catchment management authorities need to provide a balanced approach in considering the catchment as a whole and therefore they should have greater influence on all public and private land in catchment planning. This means that the catchment management authorities are currently not providing an holistic catchment management approach.

Question - Serena O'Meley

- In one of the case studies presented by Rob Vertessy, the water yield loss was estimated at 4 Megalitres per hectare. However, in Chris Tipler's presentation relating to the Otway region, it was 2.6 Megalitres per hectare. Which is correct?

Answer - Rob Vertessy

The 2.6 Megalitres per hectare is quite conservative and it could actually be more than 2.6 Megalitres per hectare. Overall, an individual Kuczera curve should be developed for each logging area or coupe so that a more accurate figure can be generated.

Comment - Chris Tipler

Believed that across all the coupes in the Otways the 2.6 Megalitres per hectare was the average amount of water lost.

Comment - Rae Moran

In the Otways stored soil moisture is significantly less than in other Victorian forests. The loss per hectare really depends on what you start with in terms of soil type, vegetation and rainfall. The figure can be very site specific. In some areas of the Barwon catchment it could be as low as 0.7 Megalitres per hectare, significantly less than the 2.6 Megalitres per hectare that Chris Tipler cited. Records need to be kept in order to make precise statements about the amount of water loss from various areas in the Otway region.

Question - Paul Northey

The region is now facing water restrictions. We can be sure that timber harvesting is not responsible for the movement towards phase 2 water restrictions. What research do we really need to know to find out the effect of land cover and water yield?

Answer - Rob Vertessy

A lot more work needs to be done on water yield and that some of this can be done without embarking on huge research projects. It is a great shame that catchment research has been cut back as local communities do not necessarily trust generic models and are much more likely to trust information that is sourced from their local area. There is a need for the community to be involved in more monitoring and evaluation of changes in their own regions.

Answer - Chris Tipler

If you take a long-term view of the management of the Otway forests, then the average numbers for the Otways that have been used in the presentations are acceptable. Overall, we should be applying the precautionary principle and timber harvesting should be stopped until we can work out the exact relationship between timber harvesting and water yield.

- **Question - Simon Birrell**

- Under section 6.5.4 of the Otway Forest Management Plan there is a requirement for hydrologic research to be included in the Regional Forest Agreement process. However, this research was never finished and it was in fact terminated in 1994. Why was the Silvicultural Systems Project terminated in 1994 and how can the requirements of the Plan be met when there is no hydrologic research going ahead?

Answer - Kylie White

Could not answer on behalf of the Department of Natural Resources and Environment in relation to the Silvicultural Systems Project.

Answer - Rob Vertessy

It is a world-wide trend to cut long-term catchment research involving monitoring and evaluation. Such research is costly and most departments do not appear to have the resources.

Answer - Kylie White

The Department of Natural Resources and Environment approached the rural water authorities and local water authorities to assist with the Silvicultural Systems Project. However, they were not forthcoming in providing funds to assist the project.

- **Question - Michael Fox**

- Concern that a boardwalk constructed in a part of a river is subject to flooding. How could this mistake be made? The boardwalk has now had to be closed.

Answer

Facilitator suggested the question be taken as a statement.

- **Question - Chris Dare**

- Has the cost of producing water been compared with the cost of treating water for human consumption?

Answer - Chris Tipler

The work undertaken on estimating the costs associated with water production is in its infancy. There is an urgent need for more research in this area especially in the unit cost of producing treated water for human consumption.

Answer - Loris Duclos

The Commonwealth should undertake a full economic analysis of the value of water compared with the forest industries in the region including the contributions they make to the regional economy. Without a full economic analysis it is difficult to make informed decisions on which to base a Regional Forest Agreement.

- **Question - Debbie Mauric**

- If road usage is the major cause of sediment run-off affecting water quality, is sealing the problem roads the answer?

Answer - Panel

The costs of sealing would have to be borne by all users of these roads.

Comment - Loris Duclos

The big logging trucks should be asked to contribute to road maintenance costs as well.

- **Question – Kersten Gentle**

- The Government did not invite the forest industry to speak at the water forum. The forum should look to the future. Areas that are clear felled heal in a few years' time. The forest grows back again.

Answer

The facilitator suggested this be taken as a statement.

- **Question - Cameron Steele**

- It is accepted that clear felling reduces water yield. Would different techniques of logging the forests such as abandoning clearfelling in favour of different patterns of thinning be a better option from a water yield point of view?

Answer - Kylie White

Timber harvesting does reduce water yield. However, it is a matter of the scale and pattern used in timber harvesting. The Otway forests are multiple aged and the logging is spread across a number of catchments over time.

Answer - Chris Tipler

Does not accept Kylie White's comments. Twenty to thirty per cent of the catchment is logged and that there is a linear relationship between the area logged and water yield. On economic grounds alone there is no justification for the continuation of the forest industry when the industry supplies only a few jobs.

Answer - Pat O'Shaughnessy

There is little evidence regarding the relationship between water yield and the age of native forest. The water yield - age relationship research that is being done elsewhere would probably apply to the Otways. Research is required over longer periods to be able to make links confidently regarding the relationship between water yield and forest age.

- **Question - Mark Trengove**

- The Smart Move Campaign is all about growth for Geelong, and for this water will be necessary. Perhaps we should be leaving our old growth forests until we know the answers to what is going on?

Answer

The facilitator suggested this be taken as a statement.

Summary Comments

Summary comments for each of the presentations by the facilitator Michael Williams

Pat O'Shaughnessy - an historical review of research and the regulation of forest and water issues in Victoria

- Codes of practice are an important aspect of regulating the forest industries.
- There is a need to widen the application of codes of practice to public and private land.
- There is a need to manage stream road crossings as they are a significant source of sediment to catchments.

Tim Fletcher - local catchments, stream indexing, multiple use and the impacts on water

- There are varying values of water and waterways. These values depend to a large degree on community values of water and waterways.
- There are a range of impacts that affect land and waterways in catchments.
- There are five key components to the index of stream condition:
 - Hydrology;
 - Physical form;
 - Riparian zone;
 - Water quality; and
 - Aquatic life.
- The index of stream condition for the Otways forest catchments is ranked as being of excellent water quality.
- There is a need for long-term environmental monitoring.

Chris Tipler, - water yield - implications of the evidence

- Based on valuing the timber harvested from the Otways and valuing water lost as a result of logging, there is no sound economic argument to support logging in the Otway catchments.

Loris Duclos - Midland ground water issues

- Use of scientific literature has been selectively applied to support particular positions and arguments.
- There is a need to take care in applying generic scientific rules at a site specific or local scale.
- There is a need for a greater depth of information to base any RFA decisions.
- There is a need to rethink proposed localities for new pine plantations in the region.

Jacky Croke - forest operations and water quality

- There is a need to re-evaluate the range of questions asked by scientists when studying catchment processes and management.
- It is clear that sediment from roads is the major contributor of sediment in forested catchments under timber harvesting and channelled flow is the key pathway that delivers sediment to the stream network.
- There is a need for constant improvement in best management practices as these have been proven to regulate and assist in the effective management of forests.

Rob Vertessy - forest operations and water yield

- Focused on the effect of logging on stream flow.
- It is well established that pine plantations reduce stream flow to a greater extent than native forests.
- Decline in stream flow when old growth forests are replaced by a young regenerating forests can be largely explained by the change in forest structure and growth rates. It is also related to climate and soil depth.
- The peak reduction in stream flow occurs within a few years after logging has taken place.

Kylie White - forest management planning processes

- Explained the range of different regulatory and prescriptive codes applying to the timber industry.

Broad Themes developed by facilitator Michael Williams arising out of the presentations and panel question and answer session

- There is a need for detailed science to support the development of public policy where community values range across a broad spectrum;
- There is a need for policy makers to engage with relevant scientific researchers;
- There is a real need for information sharing where complex scientific issues are at stake;
- Engaging scientists, the community and policy makers as part of the debate is most important;
- There is a need to recognise that forest management involves a complex suite of issues and that the values we ascribe to the forests are often based on personal values; and
- Overall, forest management is a conundrum about how we manage the different uses of our forests and how we reconcile the different values placed upon those uses by the community

Where to from here? - Andrew Maclean Department of Natural Resources and Environment

- It is encouraging that people have come together to consider the issue of forest and water management.
- The Regional Forest Agreement is seeking to find a balance between the range of forest uses.
- Dealing with a tough decision making process.
- The water forum provides transparency to the information that is being used to prepare the RFA.
- The forum has contributed to the RFA discussion, with participants better informed about the issues to be resolved. This, in turn, leads to the local community being better equipped to participate in the RFA process and importantly to understand and acknowledge the wide range of views on the matter.
- The newly elected Victorian government is committed to public participation and some time lines in relation to the RFA process may need to be altered to effect greater public participation. However the overall deadline for the RFA to be completed is the 31st of March 2000.
- Thanks to all who participated in the water forum and anticipate that the community will continue with their active participation over the coming months in the RFA process.
- A summary of the forum proceedings will be provided to the RFA Steering Committee for consideration and will be included in the West Victoria RFA - Direction Report.

Appendix 1

List of those that attended the West Victoria RFA Water Forum

Geelong - 1 December 1999

FIRST NAME	LAST NAME	ORGANIZATION NAME	CITY
Gareth	Finlay	Central Highlands Water	BALLARAT
Bruce	Humphries	City of Greater Geelong	GEELONG
John	Corrigan	Eureka Timber Co	SOUTH BALLARAT
Geoff	Proctor	Black Forest Timber	WOODEND
Chris Steve	Dare Rossey	Midway P/L	NORTH GEELONG
John	Hutchin	Victorian Recreational Fishing Peak Body	EAST MELBOURNE
Rod	Anderson	Environment Victoria	NORTH MELBOURNE
Tim	Anderson	Wombat Forest Society	DAYLESFORD
Matt	Armstrong	Wongarra Landcare Group	WONGARRA
Peter Jane Jackie	Attiwill Fewings England	School of Botany	PARKVILLE
Jeanette	Bellchambers	Leigh Catchment Group	SHETFORD
Stuart	Bennett	WH Bennett and Sons Pty Ltd	BIRREGURRA
Simon Roe Simone Fiona	Birrell Lees Fulton Nelson	Otway Ranges Environmental Network	ASCOT VALE
Andrew	Boyle	Thompsons Creek Catchment Committee	TORQUAY
Paul	Northey	Barwon Water	GEELONG
John	Endacott	Wombat Forest Society	HEPBURN SPRINGS
Don John Robert	Forsythe McDonald Carraill	Corangamite Catchment Management Authority	COLAC
Kersten	Gentle	Forest Protection Society	HEALESVILLE
Graeme Jon Gail	Gooding Drohan Chrisfield	Victorian Association of Forest Industries	MELBOURNE
Bill	Gill	Warrnambool City Council	WARRNAMBOOL
Kath	Gosden	Corangamite Shire	CAMPERDOWN
Pat David	Liffman Rogers	Blackwood/Barry's Reef Landcare Group	TRENTHAM
Paul	Love	CFMEU	WENDOUREE
Chris	Windfield	Brisbane Ranges Landcare Group	BALLIANG
Stuart	McCallum	Friends of Bannockburn Bush	BANNOCKBURN
Gavan	McFadzean	Wilderness Society	MELBOURNE
Lee	Murnane	Beaufort Sawmills	BEAUFORT
Belinda	Murnane	Otway Forest Industries Information Group	COLAC
Paul Richard	Northey Riodan	Barwon Water	GEELONG
Amy	O'Brien	Future Rescue	ALLANSFORD
Amy	Lehmann	Deakin Uni Warrnambool	WARRNAMBOOL
Serena	O'Meley	Geelong Community Forum	GEELONG
Wendy David	Briggs Fenn	Colac Otway Shire	COLAC
Rowan	Reid	School of Forestry	PARKVILLE
Graeme	Saddington	Barwon Water	GROVEDALE
Ira	Savage	Geelong Field Naturalist Club	HERNE HILL

Glenda	Shomaly	Torquay Coast Action Group	TORQUAY
Barry Graham Alison	Lingham Tribe Watson	Geelong Field Naturalists	BELMONT
Anne	Wallis	Deakin University	WARRNAMBOOL
Russell Peter	Worland Morgan	South West Water	WARRNAMBOOL
David Kevin	Lenn Black	Geelong Landcare Network	
Mark Trish	Trengove Edward	Geelong residents	GEELONG
Jerry	Cross	Forest Industry Newspaper	
Michael	Fox	Friends of Lerderberg	
Cameron	Steele	Geelong Community Forum	
David	May	EPA - Geelong	
Bernie	O'Kane	CMSA	
Alison	Ingamells	Friends of the Earth	
David	Burroughs		
Malcom	McDougall	Byon sawmill	
Carol	Wilmink		
Claire	Miller	Environment Reporter The Age	
Doug	Rolfe	Geelong Christian College	GEELONG
Wade	Pearce	Geelong Independent Newspaper	GEELONG
Colleen Mary	McGee Wheeler	CFMEU/OCHA	COLAC
Tom Svea Mark	Fox Pitman Dixon	Future Rescue	GEELONG WEST

Victorian Department of Natural Resources and Environment

Justin Cook
Peter Tange
Lucy Gannon
Andrew Maclean
Kylie White
Rae Moran
Peter Keppel
Heather Adams

Commonwealth Government

Catharine Masters - Department of Prime Minister and Cabinet
Dougal Morrison - Agriculture, Fisheries and Forestry - Australia
Vanessa Hill - Agriculture, Fisheries and Forestry - Australia
Ruth Dewsbury - Agriculture, Fisheries and Forestry - Australia
Ray Spencer - Bureau of Rural Sciences
Pam Robinson - Victorian Forest Community Co-ordinator

Speakers and panel members

Pat O'Shaughnessy
Dr Tim Fletcher
Chris Tipler
Loris Duclos
Dr Jacky Croke
Dr Rob Vertessy
Kylie White
Phil Dyson (panel member)

Facilitator, forum recording and report preparation

Michael Williams
Dr Siwan Lovett

Appendix 2

Dr Tim Fletcher presentation

Appendix 3

Chris Tipler presentation

Appendix 4

Loris Duclos presentation

Appendix 5

Dr Jacky Croke presentation

Appendix 6

Dr Rob Vertessy presentation