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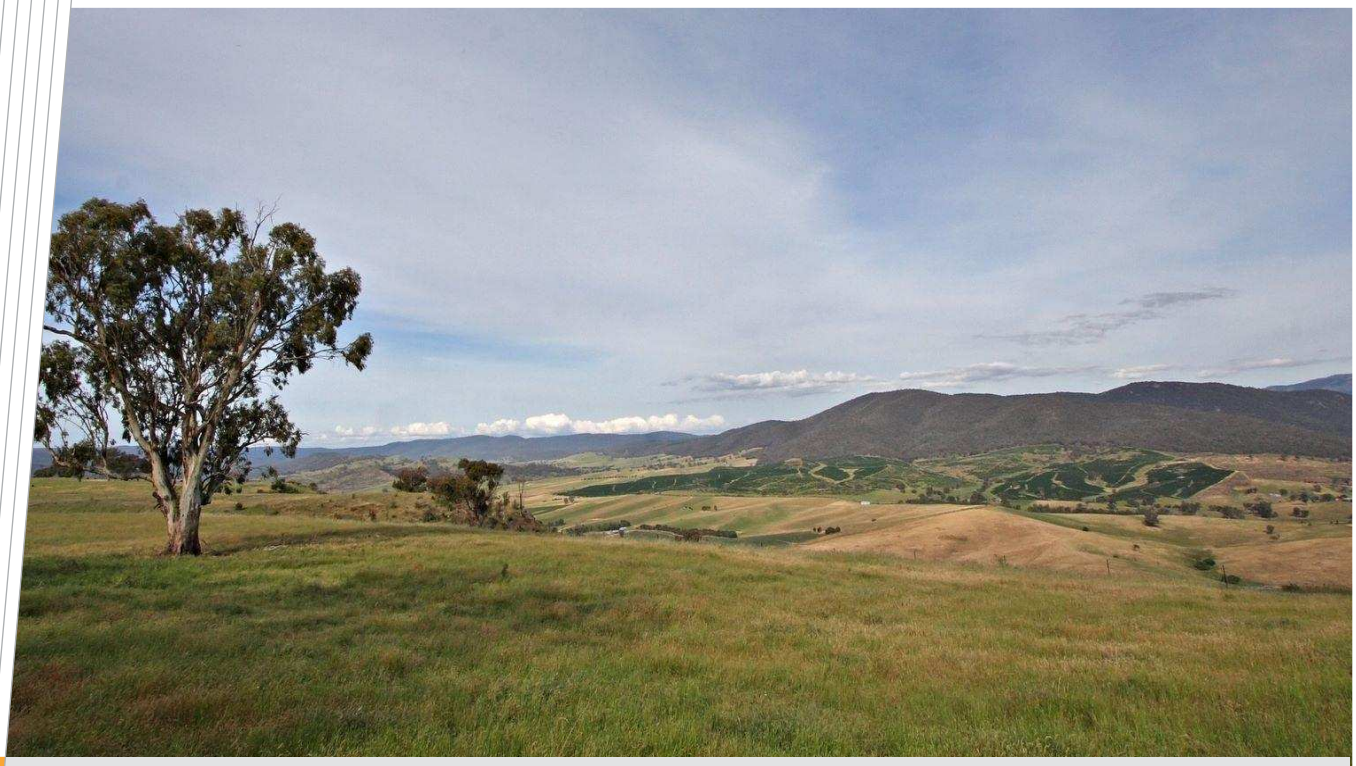

Methods to Accurately Assess Water Allocation Impacts of Plantations: FCFC Modelling Workshops Summary

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Cover Photograph:

Description: Maragle Creek from Tooma Rd, nr Corryong, NSW
Photographer: Mat Gilfedder

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ACKNOWLEDGMENTS

This project is a National Water Commission (NWC) initiative, funded through its Raising National Water Standards Program. The project is funded through the NWC, CSIRO and Forest & Wood Products Australia (FWPA) Project: 'Methods to Accurately Assess Water Allocation Impacts of Plantations'.

1. INTRODUCTION

1.1. Background

The “Methods to Accurately Assess Water Allocation Impacts of Plantations” project aims to develop methods to improve the accuracy of the assessment of the surface water allocation impacts of plantations. The first component of the project is the application of the Forest Cover Flow Change (FCFC) model (Brown *et al.* 2006) to a range of case-study catchments. A series of workshops were held to communicate the results of this section of the project, and to gain feedback on the FCFC modelling and case-study selections.

This report outlines the workshops themselves, a list of actions from the workshops, brief background on the FCFC modelling methodology, and more detailed summaries from each of the workshops.

1.2. Workshops

The National Water Commission (NWC), CSIRO and Forest & Wood Products Australia (FWPA) project held seven one-day workshops around Australia in June/July 2009. These workshops aimed to present background material on the impacts of plantation forestry on catchment water yield, discuss the supporting evidence from paired catchment and experimental catchment studies, show supporting data at a plot scale, describe the FCFC modelling approach, and present results from integration of FCFC results with river management models. FCFC provides catchment-scale predictions of the impacts of plantations on mean annual flows and daily flow durations.

The workshops were targeted at those with a need to understand the impacts of plantations on water resources. They presented preliminary results from testing and application of the FCFC model to a range of case-study catchments. Before finalising this analysis, we were seeking feedback from potential users on how to make the results most beneficial to them and how to link with local water allocation models to enable the potential effects of new plantations on water allocations to be better explored.

The workshops included presentations on:

- A brief overview of the project, describing its aims and expected outputs and outcomes.
- Detailed presentations describing:
    - How the study catchments were chosen and an analysis of trends in stream-flow from these catchments over the past 20 to 30 years
    - The development of the FCFC model and a summary of the underlying science
    - The results of applying this model to the study catchments to date to test the model and estimate changes in flows.
- Discussions with potential users as to how best to use the model for assessing impacts of new plantations on water allocations in surface water catchments, including how to link the model outputs with local water allocation models.
- A summary presentation on CSIRO research on the impacts of plantations on groundwater resources.

1.3. Attendees

Lists of potential attendees were obtained from State Project Steering Committee members, as well as through personal contacts. Additional interest was obtained "virally" with invitees suggesting other interested people. In addition to project staff, we had an average of 10 attendees at each workshop (ranging from 7 in Darwin, up to 14 in Perth). Attendees typically encompassed Agency staff from both the "water" and "forest" areas, policy staff, and staff from timber industry groups. A full list of attendees, and titles/organisations represented (where known) are given in the accounts for each individual workshop.

A possible workshop for Hobart was postponed until a later date, in order to avoid confusion with the Tasmanian Sustainable Yields project. It is possible that we will reschedule the workshop for December 2009 if that appears more suitable.

The running of these 7 workshops was a time-consuming process, although it has been a significant and useful communication exercise. Awareness of the FCFC approach used in the first stage of this project has been raised, and there was generally a positive attitude towards the FCFC approach. Additional feedback on the chosen case-studies was received.

2. FCFC MODEL

2.1. Overview of FCFC Model

It is generally understood that plantations affect not only rainfall interception, which directly influences surface runoff, but also deep drainage, which in turn determines the amount of base-flow in a catchment. However, it is difficult to quantify these changes in catchments where no detailed experimental data is available since the relative role of plantations in controlling these processes depends upon climate, vegetation, soil, and other catchment characteristics. One way to evaluate the effect of afforestation on flow regimes is to examine changes in flow duration curves (FDCs) following the establishment of plantations. A FDC represents the relationship between the magnitude and frequency of daily, weekly, monthly (or some other time interval of) stream-flow, and thus provides a measurement of the time percentage a given stream-flow was equalled (or exceeded) in the period of measurement. A FDC provides a simple, yet comprehensive, graphical view of the overall historical variability associated with stream-flow and is the complement of the cumulative distribution function of daily stream-flow. Each value of discharge (Q) has a corresponding exceedance probability p, and a FDC is simply a plot of Q_p, the p^{th} quantile or percentile of stream-flow versus exceedance probability p, where p is defined by:

$$p = 1 - p\{Q \le q\} \tag{1}$$

The quantile Q_p is a function of the observed stream-flows, and since this function depends upon observations, it is often termed the empirical quantile function (Vogel & Fennessey, 1994).

The Forest Cover Flow Change model (FCFC) is designed to adjust a time series of observed or simulated daily flow to account for changes in forest cover (Brown *et al.,* 2006). FCFC is a relatively simple tool using a wizard style interface that steps through input data, analysis and generation of new time series of flows. Users can readily generate different time series of flow for different proportions of forest cover.

In order to predict the effects of forest cover change on streamflow regime it is necessary to determine a parameterisation of the FDC that captures the key components of the curve. It is also important that the parameterisation be linked to known catchment properties and/or predicted changes in streamflow. The FDC model is expressed as:

$$Q = \begin{cases} \left(10^{a/c_1} \times \exp\left(F^{-1}\left(\frac{x}{CTF}\right)c_1\right) - a/c_1\right) P_{50}, x \le \frac{CTF}{2} \\ \left(10^{a/c_2} \times \exp\left(F^{-1}\left(\frac{x}{CTF}\right)c_2\right) - a/c_2\right) P_{50}, \frac{CTF}{2} \le x < CTF \\ 0, x \ge CTF \end{cases} \tag{2}$$

where: Q is the predicted flow, F^{-1} is the inverse of the standard normal cumulative distribution, P_{50} is the median of the non-zero flow days, CTF is the cease-to-flow percentile (expressed as a percentage), x is a probability value (0-100%) and s, c_1, c_2 are curve fitting parameters. A threshold value for cease-to-flow has been adopted for all catchments as when flow drops to 0.001 mm/day. The s, c_1 and c_2 parameters relate to different sections of

the FDC after it has been normalised by plotting it in log-normal space, with *s* being the slope at the origin of the normalised FDC (NFDC) [and c_1 and c_2 being the exponents for the upper and lower sections of the normalised FDC (NFDC), respectively.

Figure 1 shows the method used to normalise the FDC of perennial and ephemeral streams. Firstly, the cease-to-flow (CTF) percentile is established (Figure 1a). The CTF percentile is defined as the ratio of the number of non-zero flow days to the total number of days [defined as a day when flow exceeds 0.001 mm/day]. A FDC is then constructed using only the days on which flow is greater than the threshold value as streamflow measurements below this value are considered unreliable (Figure 1b). The FDC for the days of flow is then normalised by dividing all flow values by the conditional median (Figure 1c). The conditional median is defined as the median flow of the days on which flow occurs. Finally, the FDC is plotted in log-normal space (Figure 1d) to produce an NFDC. This normalisation procedure results in all of the NFDCs intersecting the origin.

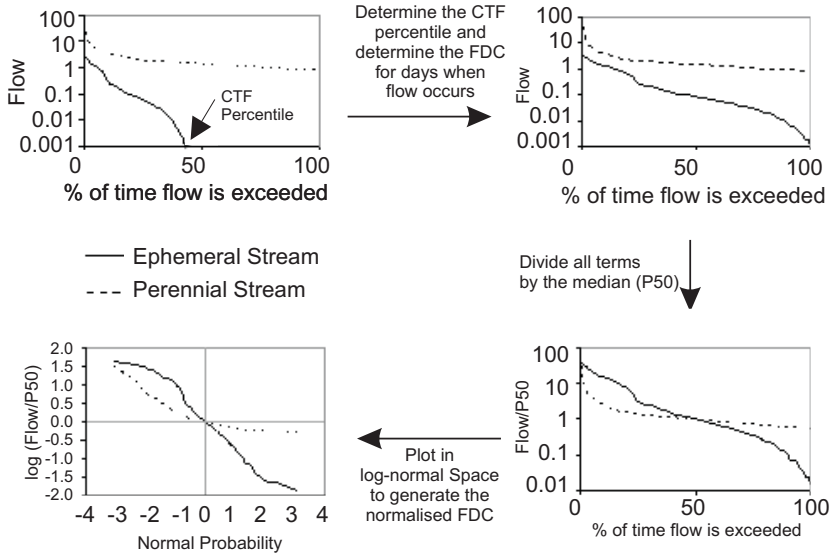

Figure 1 Normalising the FDC to achieve common parameter space.

2.2. Input and output data

The inputs to FCFC are as follows:

- **Rainfall** – a continuous time series of rainfall data that represents the rainfall across the catchment,
- **Potential evapotranspiration** – a continuous time series of potential evapotranspiration data that represents the potential evapotranspiration across the catchment,
- **Streamflow** – daily streamflow values at the outlet of the catchment. This data may be observed at a gauging station or come from another model. This data are used for model calibration and generation of new flow time series,
- **Proportion of forest cover** – This is used to represent the forest cover conditions that existed during the time series of flow data.
- **Catchment area** – This is required for conversion depth of runoff for flow inputs or outputs.

The outputs from FCFC are:

- times series of daily flows, or
- FDC modified for forest cover change.

2.3. Model parameters and calibration procedure

The FDC parameters are the CTF percentile, the conditional median and three curve-fitting parameters for the NFDC, referred to as the slope (*s*), upper exponent (c_1) and lower exponent (c_2). The CTF percentile and the conditional median are determined directly from the observed data while the curve fitting parameters are fitted using a two stage iterative process.

s, c_1, and c_2 are adjusted to minimise the sum of squared error of the difference between the observed and fitted FDCs. The upper exponent is then adjusted to achieve a mass balance between the fitted curve and the observed data.

The quality of the fit of the FDC to the data is judged using the coefficient of efficiency, *E*, calculated in the log domain (Nash and Sutchiffe, 1970):

$$E = 1 - \frac{\sum_{i=1}^{CTF} \left(\log(O) - \log(P)\right)^2}{\sum_{i=1}^{CTF} \left(\log(O) - \log(\overline{O})\right)^2} \quad (3)$$

Here, *O* is the observed percentile flow and *P* is the predicted percentile flow. The closer the coefficient of efficiency is to one the better the fit. The logarithm of the values is used to give more weight to low flow values. *E* is calculated only between the first percentile and the CTF percentile, thus zero flows are not considered. Only years with $E \geq 0.97$ are used in the subsequent analysis. Once the parameters for each annual FDC are determined, the representative values of *s* and c_1 are estimated as the mean of each of the *s* and c_1 values for all the pre-treatment years with $E \geq 0.97$. It is initially assumed that these parameters remain unchanged following a change in forest cover.

2.4. Points of clarifications

FCFC is designed to investigate the impacts of changes in forest cover on flow. The amount of data used to validate this model was limited. The major data sets used to assess the method were from Australia and South Africa, for catchments sized from 18 - 320 ha.

When using this tool the modeller needs to take into consideration that:

- This tool uses several optimisers to find the optimum solution for fitting flow duration curves and estimating a single bucket rainfall runoff model. Under certain circumstances this may not reach a suitable solution, in such cases the model will give an error message. This tool is not appropriate for these catchments.
- A result screen is provided so that modellers can assess the fit of the model. If the fit is too poor then this tool should not be used for generating flows.
- Generated flows should be checked to ensure that the change in flows is consistent with the change in forest cover.
- This tool is only appropriate for changes in forest cover and is not appropriate for other land use changes.
- The tool is not appropriate in catchments with significant irrigation or regulation.

3. WORKSHOP SUMMARIES

A short summary of main discussion points, the agenda, and a list of attendees, and key actions, for each workshop is given for each of the 7 workshops.

3.1. Brisbane

Brisbane workshop was held at CSIRO Long Pocket Labs on June 18th 2009. It was a successful and interactive (with lots of discussion) workshop. Attendees represented a range of organisations in SEQ.

3.1.1. Agenda

Introduction/Background	Aims of the workshop, overview of the project, expected outcomes
Impacts on water resources	Review of different approaches/scales, paired catchment studies, changes in larger catchments.
Forest Cover Flow Change (FCFC) model	Description, application and testing
Data to support FCFC - Plot scale work etc	Present data on ET variation, impacts on groundwater, overview of site-scale work
Project case studies	Description, presentation of results, gaining feedback, discussion
FCFC links to water allocation models	

3.1.2. Attendees

1. Ken Bubb — Manager - Plantation Development and Innovation, Forestry Plantations Queensland.
2. Jim Burgess — Resource and Environment Manager, Timber Queensland.
3. Rohan Allen — Principal Industry Development Officer - Wood Plantations, QLD Queensland Primary Industries and Fisheries (part of the Department of Employment, Economic Development and Innovation).
4. Brendan Moon — Queensland Water Infrastructure.
5. Liliana Williamson — Policy Officer, Strategic Water Policy, Strategic Water Initiatives, Qld Department of Environment and Resource Management.
6. Paul Hope — Principal Project Officer, Regional Water Supplies, Strategic Water Initiatives, QLD Department of Environment and Resource Management.
7. Alex Loy — Water Assessment Group, QLD Department of Environment and Resource Management.
8. Alma Mahmutovic — Principal Hydrologist, Water Assessment, Natural Resource Sciences Water Assessment Group, QLD Department of Environment and Resource Management.

3.1.3. Key discussion points

- Selection of Tinana CK as a case-study was debated – there are possible issues with water extractions, etc. Suggestions for other more suitable options e.g. Baffle Ck, and Amamoor Ck will be followed up by Lu Zhang with hydrographers in that area.
- Not being able to detect an impact is different from “no impact”. Signal from plantation impacts may be overwhelmed by climate, water extractions, etc.

3.1.4. Key actions

- Lu Zhang to contact hydrographer (Ray Maynard?) to obtain gauging data for Baffle Ck case study as an alternative to Tinana Ck.

3.2. Perth Workshop

Perth workshop was held at CSIRO Floreat on June 23 2009.

3.2.1. Agenda

Introduction/Background	Aims of the workshop, overview of the project, expected outcomes
Impacts on water resources - review	Review of different approaches/scales
Impacts on water resources – paired catchment and larger catchments	Paired catchment studies, and changes in larger catchments
Data to support FCFC - Plot scale work etc	Present data on ET variation, impacts on groundwater, overview of site-scale work
Forest Cover Flow Change (FCFC) model	Description, application and testing
Project case studies	Description, presentation of results, gaining feedback, discussion
FCFC links to water allocation models	
DOW Project	Presentation by Renee

3.2.2. Attendees

1.	Renee Dixon	Senior Engineer, Salinity & Water Resource Recovery Branch, WA Department of Water.
2.	Ken Mcintosh	WA Department of Water.
3.	Phil Roberts	Program Manager, Land and Clearing Management, WA Department of Water.
4.	Jacqui Durrant	Senior Engineer, Water Resource Assessment Branch, WA Department of Water.
5.	Richard Silberstein	Principal Research Scientist, CSIRO Land and Water, Perth.
6.	Stuart Crombie	WA Forest Products Commission.
7.	Clive Hampton	WA Forest Products Commission.
8.	Mohammed Bari	Supervising Chief Hydrologist, Division of Water, Bureau of Meteorology.
9.	Keith Barrett	Water Corporation.
10.	Charles Jeevaraj	Senior Engineer, Infrastructure Planning Branch, Water Corporation.
11.	Amanda Reed	Senior Engineer, Water Corporation.
12.	Richard George	WA Dept of Agriculture and Food.
13.	John McGrath	Manager Forest Science & Resources Branch, WA Forest Products Commission.
14.	Paul Raper	Hydrologist, Dept of Agriculture and Food.

3.2.3. Key discussion points

- Well attended – with staff from a range of government organisations. Including a presentation by Renee Dixon (DOW) on a proposed project which will build on the FCFC work in WA.
- Advised that case studies are a good selection – but cautioned that there a strong rainfall gradients, with the plantations mainly in the drier parts (for salinity control) rather than in the wetter areas. Extractions and regulation are not problems in these areas.

- Much discussion about applying FCFC to larger catchments – issues around rainfall variability within the catchment, and still being able to detect an impact due to the relatively small proportion of area under plantations.
- Would like to see caveats placed on “how to use FCFC” so that there is strong guidance on where and where-not the approach can be used.

3.2.4. Key actions

- Lu Zhang to include sections “appropriate use for FCFC” (i.e. caveats and guidance on use) in documentation.

3.3. Adelaide Workshop

Adelaide workshop was held at Adelaide Town Hall on June 25 2009. It was a lively meeting, with 11 attendees across a spectrum of SA government departments and organisations.

3.3.1. Agenda

Introduction/Background	Aims of the workshop, overview of the project, expected outcomes
Impacts on water resources - review	Review of different approaches/scales
morning tea	
Impacts on water resources – paired catchment and larger catchments	Paired catchment studies, and changes in larger catchments
Data to support FCFC - Plot scale work etc	Present data on ET variation, impacts on groundwater, overview of site-scale work
Forest Cover Flow Change (FCFC) model	Description, application and testing
lunch	
Project case studies	Description, presentation of results, gaining feedback, discussion
FCFC links to water allocation models	
WA Dept of Water presentation	Presentation by Renee Dixon

3.3.2. Attendees

1. Noel Richards — NRM Officer, Department of Primary Industries and Resources SA, Forestry.
2. Jason Vanlaahoven — SA Department of Water, Land and Biodiversity Conservation.
3. Luke Esprey — SA Department of Water, Land and Biodiversity Conservation.
4. Bruce Murdoch — SA Department of Water, Land and Biodiversity Conservation.
5. Kim Teow — Senior Project Hydrologist, Science, SA Department of Water, Land and Biodiversity Conservation., Adelaide.
6. Grant Pearce — Manager Groundwater Resource Assessment, SA Department of Water, Land and Biodiversity Conservation., Mt Gambier.
7. Claire Harding — Hydrogeologist, SA Department of Water, Land and Biodiversity Conservation., Mt Gambier.
8. Darryl Harvey — Principal Policy Advisor, DWLBC, Adelaide.
9. Don McGuire — Principal Scientist Research, ForestrySA, Mt Gambier.
10. Jennifer Peterson — South East Natural Resources Management Board, Mt Gambier.
11. Geoff Wood — Hydrologist, SA Department of Water, Land and Biodiversity Conservation., Adelaide.

3.3.3. Key discussion points

- There was support for the chosen case studies.
- General feeling that there is only limited applicability for linking results to river management models in SA.
- Animated discussion about selection of case studies. Don McGuire and Luke Esprey to provide land-use histories for Burnt Out Ck and Mosquito Ck.

- Geoff Wood will provide figures for Naracoorte Ck to compare to Mosquito Ck.
- Discussions around location of plantations within the catchment (i.e. within catchment variability).

3.3.4. Key actions

- Lu Zhang to follow up with Luke Esprey and Don McGuire about data (gauged flows and land-use history) for Burnt Out Ck and Mosquito Ck.
- Lu Zhang to follow up with Geoff Wood about study on Naracoorte Ck (neighbour to Mosquito Ck).

3.4. Melbourne Workshop

Melbourne workshop was held at Royal College of Surgeons on July 2 2009.

3.4.1. Agenda

Introduction/Background	Aims of the workshop, overview of the project, expected outcomes
Impacts on water resources - review	Review of different approaches/scales
Impacts on water resources – paired catchment	Support from paired catchment studies
Data to support FCFC - Plot scale work etc	Present data on ET variation, impacts on groundwater, overview of site-scale work
Afternoon tea	
Forest Cover Flow Change (FCFC) model	Description, application and testing
Project case studies	Description, presentation of results, gaining feedback, discussion
FCFC links to water allocation models	

3.4.2. Attendees

1. Rae Moran — Senior Hydrologist, Sustainable Water Strategies, Office of Water, Department of Sustainability and Environment.
2. Paul Lloyd — Senior Project Officer - Sustainable Water Strategies, Office of Water, Department of Sustainability and Environment.
3. Will Guthrie — Director, Water Resource Planning, Water Entitlements & Strategies, Office of Water, Department of Sustainability and Environment.
4. Geoff Steendam — Senior Project Officer - Sustainable Water Strategies, Department of Sustainability and Environment.
5. Greg Day — Senior Policy Analyst, Department of Primary Industries.
6. Mark Sandiford — Senior Policy Analyst, Agriculture & Forest Industries, Department of Primary Industries.
7. Ashley Greenwood — Department of Forest and Ecosystem Science, The University of Melbourne.
8. Kim Lowell — Professor, Vic Dept. of Primary Industries.

3.4.3. Key discussion points

- The chosen case-study catchments are unregulated and have no downstream regulated streams with river allocation models. Vic would like to hold off on deciding whether to connect FCFC results to river models until a later date.
- Discussion around limitations of the FCFC approach (minimum time for an FDC, rainfall seasonality and distribution, climate change, land-use histories, can it be used for impacts of clearing)
- Discussion around the possible use of FCFC as a replacement for existing Vic tools? Or as an additional tool? Is comparison warranted?

3.4.4. Key actions

- Would like to see comparison of approaches in this project with existing Victorian approaches (e.g. CAT). Mat Gilfedder to follow up for site-scale work (e.g. with Brendan Christy).

3.5. Canberra Workshop

Canberra workshop was held at CSIRO Black Mountain on July 21 2009.

3.5.1. Agenda

Introduction/Background	Aims of the workshop, overview of the project, expected outcomes
Impacts on water resources - review	Review of different approaches/scales
Impacts on water resources – paired catchment	Support from paired catchment studies
Data to support FCFC - Plot scale work etc	Present data on ET variation, impacts on groundwater, overview of site-scale work
Forest Cover Flow Change (FCFC) model	Description, application and testing
Project case studies	Description, presentation of results, gaining feedback, discussion
FCFC links to water allocation models	

3.5.2. Attendees

1. Katherine Tibbitts — Program Officer, Water Resources Risk Assessment, Murray-Darlng Basin Authority.
2. Nigel Hayball — Manager, Water Planning and Policy, Water Reform Group, National Water Commission.
3. Sonia Fedorow — Water Planning, Water Resources branch, Department of the Environment, Water, Heritage and the Arts.
4. Marita Muller — Department of the Environment, Water, Heritage and the Arts.
5. Mark Parsons — Bureau of Rural Sciences, within Department of Agriculture, Fisheries and Forestry.
6. Gavin Matthew — A3P (http://www.a3p.asn.au)
7. Daehyok Shin — Senior Hydrologist, Water Division, Bureau of Meteorology.
8. Malcolm Watson — Water Division, Bureau of Meteorology.

3.5.3. Key discussion points

- Interested in FCFC approach, also keen to see the impact of seasonal/monthly distributions. Policy makers are looking for simple tools to implement.
- Discussion on what is “starting land-use”? i.e. forest or pasture.
- Displaying results as set of incremental changes due to increasing forest cover.
- Thresholds in plantation area and being able to detect a signal in the stream flow. Discussion around the uncertainties in the climate.
- Reliability of the FCFC results? Difficulty in obtaining historical land-use data. Also noted that there are trends in other factors, not just in plantations (e.g. clearing, agricultural use, fires, water extractions, etc).

3.5.4. Key actions

- Lu Zhang to display FCFC results for a series of incremental changes from “current” (i.e. +10%, +20%. +30% plantations). To help get a feel for the sensitivity of flow duration curves to different levels of expansion.

3.6. Sydney Workshop

Sydney workshop was held at DPI offices on Elizabeth St on July 22 2009.

3.6.1. Agenda

Introduction/Background	Aims of the workshop, overview of the project, expected outcomes
Impacts on water resources – review, paired catchment	Review of different approaches/scales, Paired catchment studies.
Data to support FCFC - Plot scale work etc	Present data on ET variation, impacts on groundwater, overview of site-scale work
Forest Cover Flow Change (FCFC) model	Description, application and testing
Project case studies	Description, presentation of results, gaining feedback, discussion
FCFC links to water allocation models	
Additional time for discussion if required	

3.6.2. Attendees

1.	Stephen Elliott	Policy Manager, Water & Resources Policy Branch, Strategy, Policy & Communication Division, NSW Department of Primary Industries.
2.	Rebekah Gomez-Fort	NSW Department of Primary Industries.
3.	Susannah Kable	NSW Department of Primary Industries.
4.	Peter Regan	Research Leader, Water in Primary Industries, NSW Department of Primary Industries.
5.	Ashley Webb	Planted Forest Operations, Forests NSW, NSW Department of Primary Industries.
6.	Lisa Turner	Planted Forest Operations, Forests NSW, NSW Department of Primary Industries.
7.	Tony Dawson	Plantation Assessment, NSW Department of Primary Industries.
8.	Wayne Garrard	Plantations Policy Officer, Wollongbar, NSW Department of Primary Industries.
9.	Richard Beecham	Hydrologist, NSW Department of Water and Energy.
10.	Barbara Sanders	NSW Department of Primary Industries.
11.	Tom Nordblom	Economist; NSW Department of Primary Industries, Wagga.
12.	Remko Duursma	University of Western Sydney.

3.6.3. Key discussion points

- General support for the chosen case studies. Enthusiastic about trialling many more case studies, including in Upper Clarence, Macquarie (Baldry), Upper Murray (Mannus Ck.). There is little scope within the project to include extra case studies at this stage, as we already have 3 from NSW.
- Stephen Elliot to follow up on accessing catchment boundary information
- Tom Nordblom – keen to collaborate with respect to economic analysis

- Discussion around length-of-record required to get representative relationships.
- Discussion around the uncertainties in rainfall totals across large areas (cf small paired catchment studies)
- Keen and supportive with regard to the use of the FCFC tool.
- Happy to see impacts of plantations investigated as realistic scenarios – and not just a “worse case” scenario.

3.6.4. Key actions

- Lu Zhang to follow up with Stephen Elliot regarding catchment boundary information.

3.7. Darwin workshop

Darwin workshop was held at CSIRO Berrimah on July 30 2009.

3.7.1. Agenda

Introduction/Background	Aims of the workshop, overview of the project, expected outcomes
Impacts on water resources – review, paired catchment	Review of different approaches/scales, Paired catchment studies.
Data to support FCFC – Plot scale work etc	Present data on ET variation, impacts on groundwater, overview of site-scale work
Forest Cover Flow Change (FCFC) model	Description, application and testing
Project case studies	Description, presentation of results, gaining feedback, discussion
FCFC links to water allocation models	
Additional time for discussion if required	

3.7.2. Attendees

1. Sean Bithell — Sustainable Production Research Officer, Department of Regional Development, Primary Industry, Fisheries and Resources.
2. Jerome Paiva — Senior Engineer Water Resources Assessment, Department of Natural Resources, Environment, The Arts and Sport.
3. Chris Wicks — Water Resource Planner, NT Dept of Natural Resources, Environment, The Arts & Sport.
4. Kelly Howitt — Water Allocation Planner, Natural Resources Division, Department of Natural Resources, Environment, The Arts and Sport.
5. Ian Lancaster — Director Water Resources, Department of Natural Resources, Environment, The Arts and Sport.
6. Peter Stephens — Plant Industries, NT Department of Regional Development, Primary Industry, Fisheries and Resources.
7. Don Riley — Forestry Research officer, NT Department of Regional Development, Primary Industry, Fisheries and Resources.

3.7.3. Key discussion points

- Long discussions about differences to other parts of Australia (importance of groundwater use, karst, forest conversion, gw ecosystems)
- Long discussion about case-study possibilities. Very few suitable places, possibly Stray Creek (Daly River), which is about the right size (1200km^2) is 10% cleared, and has plantation development. Most places have very poor gauging for our purposes.
- Focus on conversion from native forest to plantation
- Priority seems to be on protecting site specific key assets (i.e. dry season flows, groundwater springs, etc)
- Focus on groundwater use of plantations, and impact on groundwater flows to streams.
- Discussion around applicability of the models for tropical tree species.
- Limited scope for direct application of the work in this project, but happy to be kept informed. Plantation development currently small compared to catchment size, forest

conversion, plantations in areas with limited surface runoff [e.g. Tiwi Islands], limited gauge records.

- Much gauging is for floods, and height only

3.7.4. Key actions

- Lu Zhang to follow up with Chris Wicks regarding data from the most suitable case study catchment: Stray Creek catchment (near Pine Creek).

3.8. Hobart workshop

No workshop was held in Hobart – after feedback from David Nicholls (Tas. Department of Primary Industries, Parks, Water and Environment).

3.8.1. Key actions

- Mat Gilfedder to initiate contact later in 2009 regarding holding a workshop in Hobart in conjunction with the Tasmanian Sustainable Yields Project (possibly December 2009).

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