Forestry, water yields and water quality on the Koonya uplands, Tasmania – an example of a scientific enquiry addressing community concerns

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Abstract

In 2000 some residents of the Cascade Rivulet valley, Tasman Peninsula, Tasmania expressed concern that past and planned forest operations on the Koonya uplands would affect the quality and quantity of water in streams used as sources of domestic water. Consequently a multidisciplinary scientific study was conducted to assess potential forestry impacts. The study reviewed historical information, investigated the soils, geology and water yield of the uplands, and measured water quality in a number of streams including one known as Koonya B which provides water for several residents.

Because of the presence of a jointed and relatively permeable dolerite cap on the Koonya uplands, it is not known whether stream catchment boundaries precisely coincide with ridgelines. For this reason water yields were predicted for two scenarios: (1) harvest within a 250 ha area on the Koonya uplands east of the main ridgeline (the Koonya divide) separating the Cascade Rivulet valley from the Koonya uplands; (2) past and present harvest within a 58.5 ha catchment largely within the Cascade Rivulet valley, and immediately above the Koonya B water intake. Because there have been no long-term land-use impact studies on streams in Tasmania, the predictive models used Victorian water yield data; the assumptions used when applying the Victorian data to Tasmania were clearly stated.

For scenario 1, modelling showed that staged harvest of five 50 ha coupes at 5-year intervals would maintain a positive stream water balance, relative to present-day yields, until years 31–47 after harvest, when small yield decreases would occur. The average decrease over these years would be 4.5 mm, or about 1% of present-day yields, which would be undetectable. These small yield decreases occur because in the staged harvest the runoff increases that occur immediately after harvest are partly cancelled by later decreases, and also because there is a gradual increase of water yield from the maturing unharvested forest.

For scenario 2, modelling showed that stream yield has probably already increased because of the harvest of a private block of forest. Further harvest of 14.5 ha of State Forest within the assumed 58.5 ha catchment area, 11 years after the private harvest, would have minimal negative impact, largely because of the gradually increasing water yield expected from remaining unharvested maturing forest.

The study found that soils in the planned forest harvest area are formed in dolerite and have low erodibility. Such soils are resistant to harvest and machinery impacts, and turbid runoff from such soils seldom occurs. Intermittent records collected since 1994 showed that turbidity at the Koonya B intake was unlikely to be related to rainfall quantity or previous harvest within the catchment but may have been affected by local factors such as passage of spring water through silty moderate-to-high erodibility soils outside the planned forest harvest area, and soil disturbance by tree overturn.

We conclude that, regardless of whether Koonya B water is derived partly from seepage from below the Koonya uplands, or wholly from a smaller catchment directly upstream of the intake, water yield is unlikely to be significantly affected by forest harvest nearby, provided harvest is staged. We also conclude that the quality of spring and stream water in the Cascade Rivulet valley has not been significantly affected by past harvest and is unlikely to be affected by future forestry operations.

Key Words
Forestry, hydrology, community, streams, dolerite, water yield

Introduction

The Koonya uplands on the Tasman Peninsula, Tasmania are a dissected plateau of about 5 km^2 at 250–500 m altitude (Figure 1) underlain by a subhorizontal dolerite sheet which overlies Triassic sandstones and mudstones (Forsyth, 2003). The area has a mean annual rainfall of about 1050 mm (Brown, 1997) and has a cover of *Eucalyptus obliqua-E. regnans-E. globulus* forest, with some *E. delegatensis* forest at highest altitudes. The Cascade Rivulet flows in a valley running from south to north immediately west of the uplands and is fed by several small streams and springs, some of which originate in the vicinity of the dolerite-sedimentary rock contact on the steep eastern valley side.

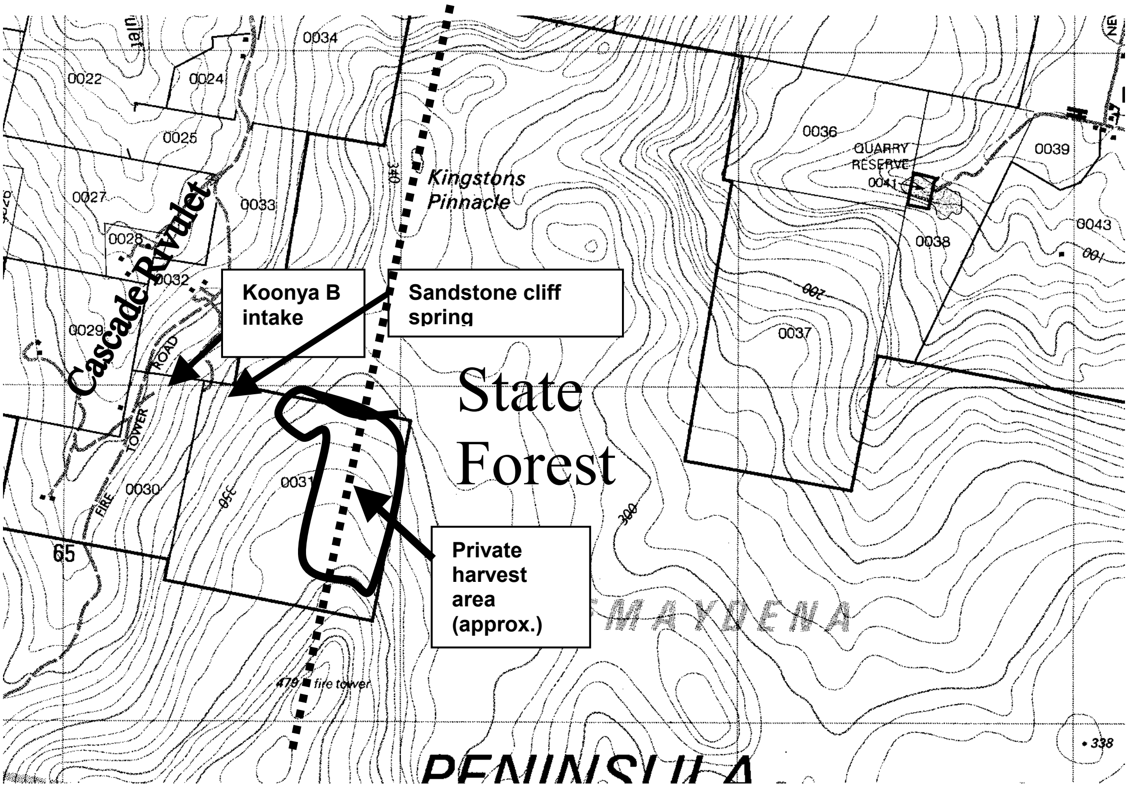

Figure 1. Outline of study area and location of the Koonya B stream intake and water sampling site. The dotted line indicates the topographic divide (Koonya divide) between the Cascade rivulet valley (to the west) and the northern Koonya uplands (to the east). Grid lines are 1000 m apart.

Several reconnaissance surveys on the possible effects of forestry operations on water supplies have been undertaken in the area (e.g. Weldon (1991) and several unpublished reports cited by McIntosh (2003)). These authors concluded that forestry operations east of the Koonya divide (the ridge line defining the western limit of the Koonya uplands) (Figure 1) are unlikely to affect spring and stream water quality and quantity in the Cascade Rivulet valley. Despite the above surveys and reports, some residents in the Cascade Rivulet valley who obtain their domestic water from the above-mentioned springs and streams have expressed renewed concern that forest harvest on the Koonya uplands could diminish water supplies and deleteriously affect water quality.

Methods

Approach

In order to address community concerns, a working party was formed consisting of representatives of Forestry Tasmania, the Department of Primary Industries, Water and Environment, the Forest Practices Board, Mineral Resources Tasmania, local residents and the Tasman Council. This working party decided to summarise the information available on soils, geology, water quality and hydrological characteristics of the Koonya uplands, so that any environmental impacts of proposed land-use changes could be assessed. It also decided that limited additional investigations would be made and that the draft report would be peer-reviewed by a respected scientist with hydrological expertise before being finalised and published.

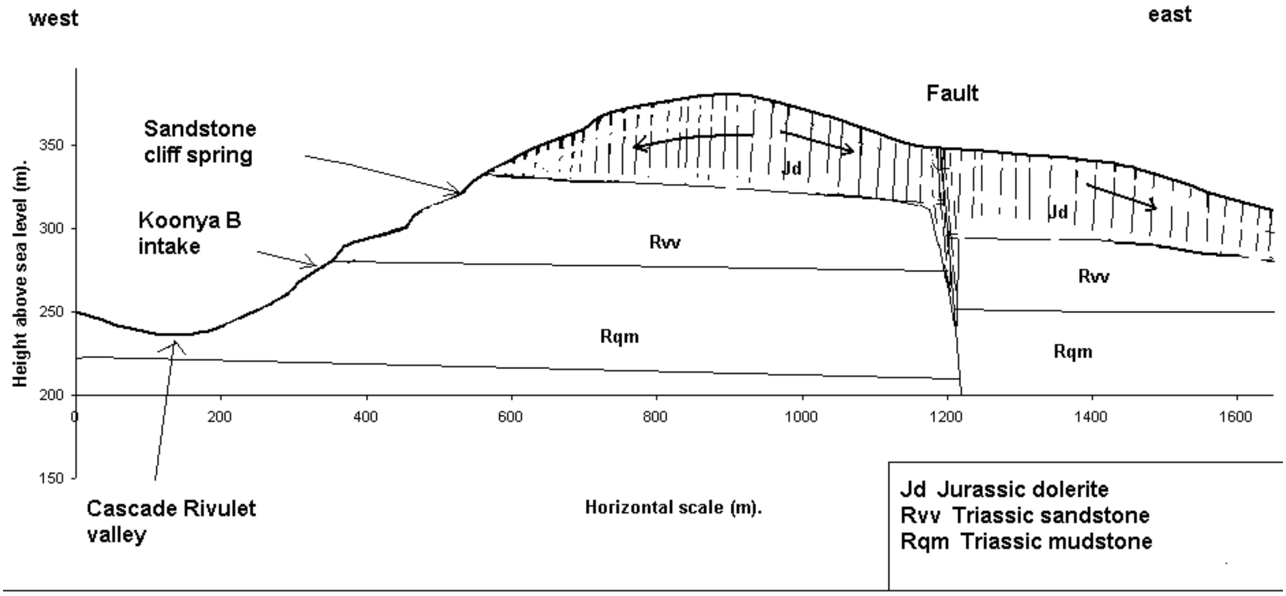

Figure 2. Geological cross-section through the Koonya uplands and the Cascade Rivulet valley showing the Jurassic dolerite cap (Jd) overlying sedimentary sandstone and mudstone (Rvv and Rqm respectively). Note that the dolerite contact with the sedimentary beds below is inclined eastwards. Possible directions of groundwater flow are indicated: it is possible that some westward flow from a conjectural aquifer in the dolerite could occur. (After Forsyth, 2003.)

Geology and Soils

Geological mapping for this project (Forsyth 2003) chiefly concentrated on determining the geometry of the contact zone between the dolerite and the underlying sedimentary rocks, as this zone could influence the direction of any deep subsurface flow. Soils were described by the methods of McDonald et al. (1990).

Water Quantity

The subsurface flow pathways in the district are not known, and there is no water yield data for streams in the district. We therefore investigated two scenarios, and used published data on forest harvest effects in upland Victorian forests, to model potential impacts on stream yields of forest harvest on the Koonya uplands. The two scenarios were: (1) forest harvest within a 250 ha area on the Koonya uplands east of the Koonya divide; this scenario assumes that the Koonya B stream receives a significant contribution from rainfall falling east of the divide; (2) past and present forest harvest within a 58.5 ha catchment largely within the Cascade Rivulet valley, immediately above the Koonya B water intake.

Assumptions for Scenario 1

Calculations were based on the Victorian Picaninny catchment data summarised by Vertessy et al. (2001). This catchment has a mean annual rainfall of 1200 mm. Before 78% of the catchment was harvested in 1972 it had a cover of old-growth *E. regnans*. The following assumptions were made:

- The Koonya forest is 60 years old; evapotranspiration and interception losses in the present forest are predicted by the Kuczera curve (Vertessy, 1999) and are about two thirds of the maximum losses which occurred when the forest was about 18–25 years old.
- On the Koonya uplands one third of the mean annual rainfall (i.e. about 350 mm) will infiltrate deep into the soil and eventually appear as streamflow. This assumption is supported by data presented by Vertessy (1999, table 6) and Vertessy et al. (2001, figure 7).
- The information for the Picaninny catchment is the best match for what is likely to occur on the Koonya uplands after harvest; both the Picaninny catchment and the Koonya uplands are formed in deeply weathered rock (granite and dolerite in the respective areas); although the Picaninny catchment has slightly higher rainfall than the Koonya uplands, higher rainfall at Picaninny may be compensated by the lower evapotranspiration on the Koonya uplands, therefore no adjustment has been made for rainfall difference.

- Using the Picaninny and Kuczera data, the smoothed maximum decrease in water yields, relative to that under old-growth forest, was about 186 mm, and the decrease under 60 year forest was about 124 mm; the latter figure is taken as applying to the present-day Koonya forest.
- Yield declines after harvest will follow those predicted by the shape of Kuczera curve and will gradually approach nil (relative to old growth forest) by the time the forest is about 200 years old; harvest of the 60 year old forest at Koonya will increase streamflow by about 124 mm *over and above* the first-year yield increase predicted using the Picaninny model.
- In order to indicate natural variation of water yields, neither the Picaninny data nor the derived data for the Koonya uplands has been smoothed.
- Within the study area the Koonya uplands will support five coupes of 50 ha each; about 78% of each coupe will be harvested by clearfell operations; the unharvested forest will cover about 22% of the 250 ha coupe area once harvest is completed and will gradually yield more water as it ages (Vertessy, 1999).

Assumptions for Scenario 2

- The total catchment area is 58.5 ha; 18 ha of this lies east of the Koonya divide.
- A private block of 13 ha was harvested in 1998 and is regenerating back to native forest.
- The area of State Forest available for harvest is 14.5 ha; this area is all east of the divide; it will be harvested in 2008.
- The rainfall and stream flow assumptions listed above for Scenario 1 also apply to Scenario 2.

Water Quality

Water quality (Total Dissolved Solids, Total Suspended Solids and Turbidity) on Koonya B stream was measured on 19 December 2002 by the methods and protocols of DPIWE (2004). Intermittent analyses of water collected at the Koonya B intake, collected by Forestry Tasmania since May 1994, used the same methods and protocols.

Results and Discussion

Geology

The major finding of relevance to this study is that the contact of the relatively permeable dolerite rock and the relatively impermeable underlying sedimentary rock dips eastwards at a small angle (Figure 2). Consequently any concentration of water at the dolerite-sedimentary rock contact is unlikely to have a major flow pathway to the east, into the Cascade Rivulet valley, although minor seepage is possible.

Soils

The soils in the proposed harvest areas are formed in dolerite (McIntosh, 2003) and classified as Dermosols and Ferrosols (Isbell 1996), which have low or moderate soil erodibility (Laffan et al., 1996). Wide experience with operations on these soils show that they are resistant to disturbance (Grant et al., 1995). Consequently operations conforming to the Forest Practices Code (Forest Practices Board, 2000) are unlikely to cause significant compaction or turbid runoff.

Outside the proposed forest harvest areas the soil survey noted several soils formed in sedimentary rocks. Of significance to this study was the presence of weakly-structured soils developed in siltstone (Kandosols), having moderate-to-high erodibility and exhibiting tunnel-gully erosion, in an area upstream of the Koonya B intake.

Water quality

Intermittent water quality measurements over 8.5 years (Figure 3) showed that high turbidity peaks were unlikely to be related to high rainfall events, and were also apparently unrelated to the 1998 harvest of a private 13 ha forest block. Since records began in 1994 the turbidity values (mean 13.5 Nephelometric Turbidity Units (NTU)) have commonly exceeded the 5 NTU ANZECC guideline for drinking water.

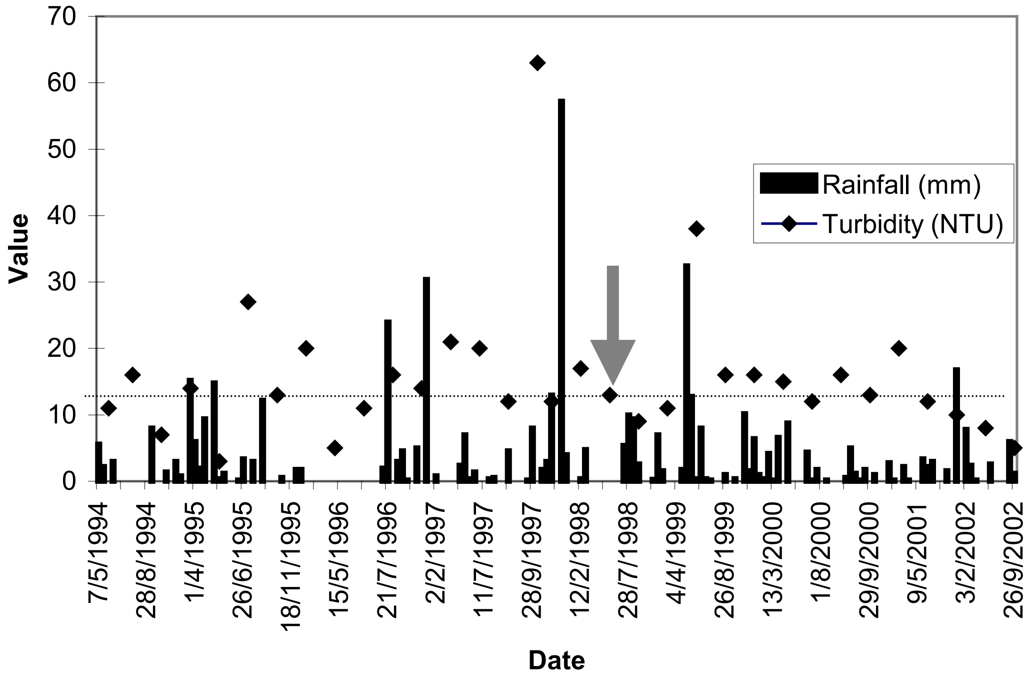

Figure 3. Turbidity at the Koonya B intake in relation to rainfall at Palmers Lookout. The bold arrow indicates the harvest date of 12 ha of private forest within the Koonya B catchment. Horizontal line is the mean turbidity value of 13.5 NTU. Plot by Kate Wilson, DPIWE, Hobart. (From McIntosh, 2003, p. 23.)

Sampling along a 300 m reach of the stream feeding the Koonya B intake showed that water quality declined between the sandstone cliff spring and the Koonya B intake (Figure 4). Both the root ball of a fallen tree and tunnel gully erosion in moderate-to-high erodibility silty soils may have contributed to the water quality decline along this stream reach. As the water quality at the Koonya B intake has been consistently poor (Figure 3), tunnel-gully erosion is the most likely cause of turbidity and siltation.

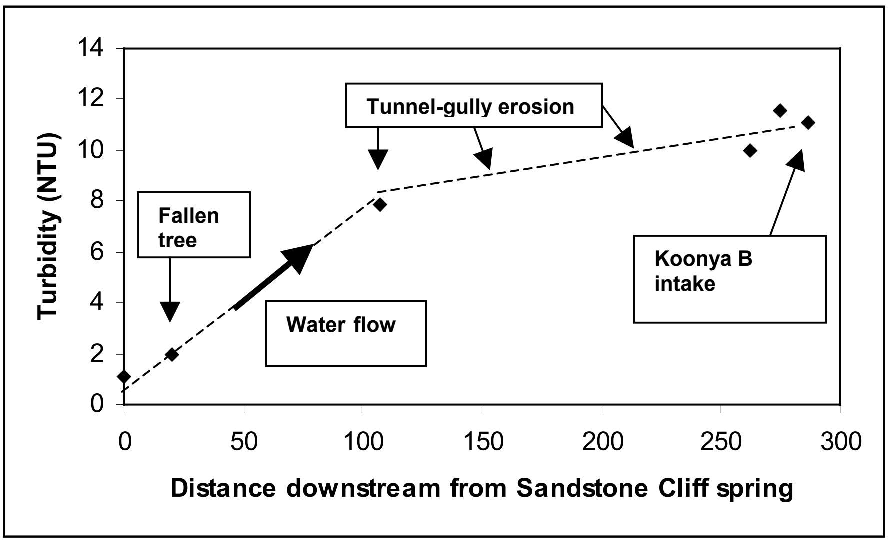

Figure 4. Mean turbidity levels at the Sandstone Cliff sampling site and at five points downstream, 19 December 2002. Curve is hand drawn. (From McIntosh, 2003, p. 25.)

Water quantity

Scenario 1

The predicted extremes of water yield change on the Koonya uplands are represented by the yield curves for no harvest and for 100% harvest (which approximates to the situation pertaining after a wildfire). If there is no harvest the gradually maturing forest will slowly yield more water as the trees age (Figure 5) as predicted by the Kuczera curve (Vertessy et al., 2001). After 60 years yields will be about 100 mm greater (29% more) than at present. In contrast, after 100% harvest in one year, yields will increase rapidly by about 150%, and then fall, with yields being less than at present for all but one year after year 12; yields would gradually increase to present-day yields as the forest approaches 60 years of age.

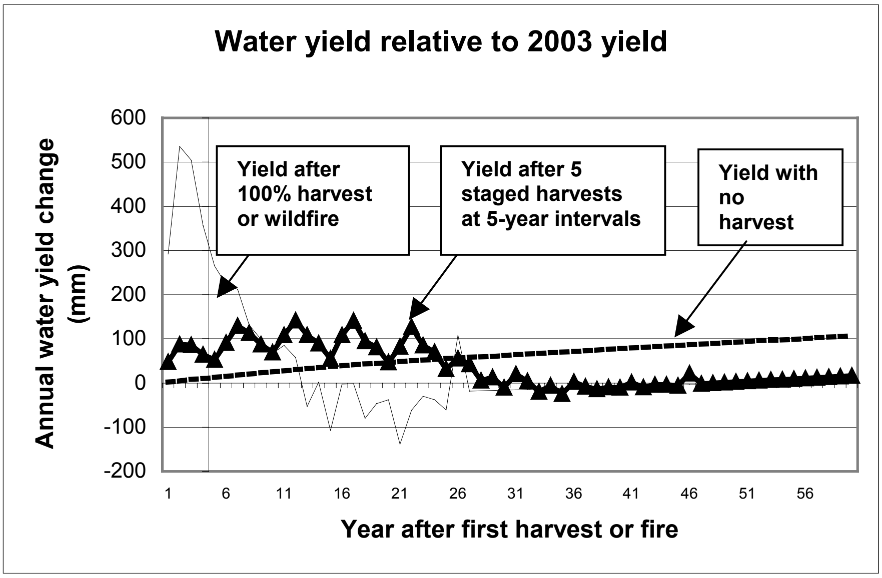

Figure 5. Predicted water yield after five coupe harvests, relative to water yield in 2003. (From McIntosh, 2003, p. 31.)

The heavy continuous line in Figure 3 represents the yield to be expected from a more realistic harvest plan: 78% harvest of five 50 ha coupes, staged at 5-year intervals. The remaining forest is allowed to mature. The maximum water yield increase is 40% (compared to a 150% increase for the 100% harvest). The 25-year spread of harvest maintains a positive water balance, relative to present-day yields, until years 31–47, in which a small mean yield decrease (4.5 mm or 1% of present-day yields) occurs. Such a decrease would be undetectable.

This analysis demonstrates that, if the springs in the Cascade Rivulet valley are partly fed by seepage from below the 250 ha area of forest planned for harvest, staged harvest at five-year intervals is unlikely to have a detectable effect on spring yields.

Scenario 2

In this scenario the total catchment area of the Koonya B stream is assumed to be 58.5 ha, the area available for commercial harvest is 14.5 ha (25% of the assumed catchment area) and a private block of 13 ha (Figure 1) has already been harvested and is regenerating back to native forest. Water yields in relation to 1998 yields have been calculated (Figure 6). Because harvest of the private block affects only a small proportion of the 58.5 ha catchment, the predicted yield decrease is cancelled by the gradually increasing yield of the maturing forest; consequently, if no further harvest occurs, no yield decrease is predicted for the 60-year period after harvest (Figure 6). Harvest of the 14.5 ha commercial forest area in year 11 initially increases yields (as predicted from the Picaninny data) and then produces a slight yield decrease in 3 of the 10 years from years 24–33. The maximum stream flow decrease is 20 mm or 6% of mean pre-harvest stream flow, which is likely to be undetectable.

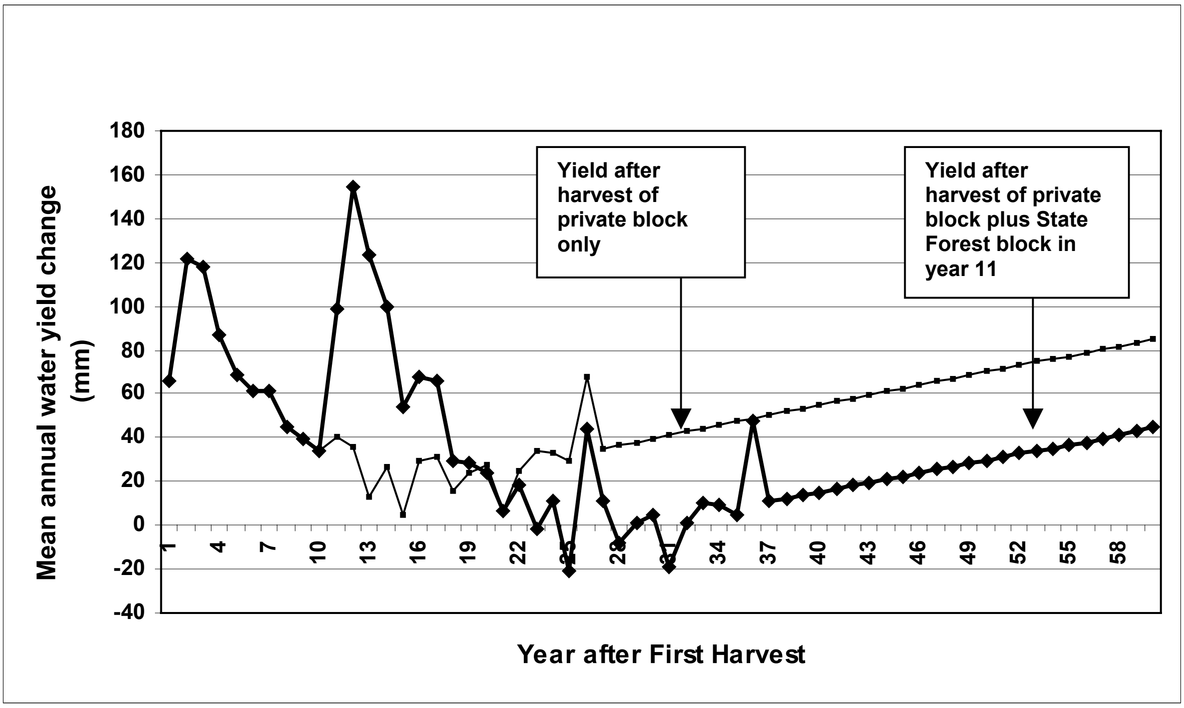

Figure 6. Predicted water yields at the Koonya B intake relative to 1998 yield, as a result of harvest on the 13 ha private block and as a result of harvest on the private block coupe plus the projected 14.5 ha state forest block in 2008 . (From McIntosh, 2003, p. 33.)

Summary, Conclusions, and Implications for Forest Management

The effects of staged forest harvest over an area of about 250 ha east of the Koonya divide were modelled over a 25-year period. The model predicted an increased water yield for the first 30 years after harvest, and then a decrease of about 1% (relative to present-day yields) for about 17 years, after which yields will increase again. The 1% yield decrease is likely to be imperceptible, either by scientific measurement or by domestic water users. Therefore, if the Koonya B stream is sourced significantly from east of the Koonya divide, forestry operations east of the divide are unlikely to have a perceptible effect on Koonya B stream flows.

When calculations were made on the assumption that the Koonya B stream had a smaller catchment mainly located west of the Koonya divide, but including 14.5 ha of State Forest east of the divide, similar very small yield decreases were predicted, with maximum effects of about –6% in some years.

The study has established no connection between recent forestry operations and turbid water at the Koonya B intake. Water monitoring since 1994 shows that water in the Koonya B intake has been habitually turbid; turbidity levels appear to have neither increased nor decreased since 1994. Tunnel gully erosion and (more recently) natural tree overturn in the Koonya B catchment may have contributed to turbidity at the Koonya B intake. The quality of spring and stream water is unlikely to be affected by future forestry operations, which will occur on low to moderate erodibility soils formed in dolerite.

The results of this environmental impact assessment support Weldon's earlier (1991) conclusion that "[the] proposed forestry management guidelines for the Koonya block are well reasoned. It is a cautious approach which should minimise the effect on stream and spring quality as well as slope instability. In reality, the effect is expected to be negligible."

As a result of the investigations summarised above, and detailed in McIntosh (2003), forest plans (Forestry Tasmania, unpublished information) were altered to increase the time between adjacent clearfelling operations to a minimum of 10 years, to restrict harvesting to at least 300 metres from the 3 known springs, and to return the harvested areas to native forest instead of converting them to hardwood plantations.

References

Brown, M. (1997). Predicted annual rainfall using ESOCLIM, 1: 250 000. DPIWE, Hobart.

DPIWE (2004). Water Quality sampling protocols. Water Assessment and Planning Branch, DPIWE, Hobart.

Forest Practices Board (2000). *Forest Practices Code.* Forest Practices Board, Hobart.

Forsyth, S. (2003). Geology of the Mount Koonya area. *Tasmanian Geological Survey Record No. 2003/08.* Mineral Resources Tasmania, Hobart.

Grant, J., Laffan, M., Hill, R., & Neilsen, W. (1995). *Forest Soils of Tasmania.* Forestry Tasmania, Hobart.

Isbell, R.F. (1996). *The Australian Soil Classification.* CSIRO, Collingwood, Vic. 143 p.

Laffan, M. D., Grant, J., & Hill, R. (1996). A method for assessing the erodibility of Tasmanian forest soils. *Australian Journal of Soil and Water Conservation 9*, 16–22.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J., & Hopkins, M.S. (1990). *Australian Soil and Land Survey Field Handbook.* CSIRO, Melbourne.

McIntosh, P.D. (Editor) (2003). Soil, water and summary reports for investigations into the effects of forestry operations on the Koonya uplands, Tasmania. Forest Practices Board, Hobart. www.fpb.tas.gov.au

Vertessy, R.A. (1999). The impacts of forestry on streamflows - a review. In J. Croke and P. Lane (Eds.), *Forest management for water quality and quantity.* Proceedings of the 2nd Forest Erosion Workshop, May 1999. Report 99/6, CRC for Catchment Hydrology, Melbourne, 108 p.

Vertessy, R.A., Watson, F.G.R. & O'Sullivan, S.K. (2001). Factors determining relations between stand age and catchment water balance in mountain ash forests. *Forest Ecology and Management, 143,* 13–26.

Weldon, B.D. (1991). Potential effects of forestry operations on slope stability and springs in the Mt Koonya area. *Division of Mines and Mineral Resources, Hobart, Report 1991/2*.