An Economic Assessment of Water Values
Upper and Lower North East CRA Regions

A project undertaken as part of the NSW Comprehensive Regional Assessments

Final Report – February 1999

ECONOMIC ASSESSMENT OF WATER VALUES: UPPER NORTH EAST AND LOWER NORTH EAST NSW CRA REGIONS

FINAL REPORT

HASSALL & ASSOCIATES PTY LTD

A project undertaken as part of the
NSW Comprehensive Regional Assessments
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This project has been jointly funded by the New South Wales and Commonwealth Governments and managed through the Resource and Conservation Division, Department of Urban Affairs and Planning, and the Forests Taskforce, Department of the Prime Minister and Cabinet.

The project has been overseen and the methodology has been developed through the Economic and Social Technical Committee, which includes representatives from the New South Wales and Commonwealth Governments and stakeholder groups.

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EXECUTIVE SUMMARY

This working paper describes a project undertaken as part of the comprehensive regional assessments of forests in New South Wales. The comprehensive regional assessments (CRAs) provide the scientific basis on which the State and Commonwealth Governments will sign regional forest agreements (RFAs) for major forest areas of New South Wales. These agreements will determine the future of these forests, providing a balance between conservation and ecologically sustainable use of forest resources.

Project objectives

There were three primary objectives of this project. Firstly, to estimate the potential economic impacts of changes in water quantity and quality from forest catchments. Secondly, to focus on a selection of NSW forested catchments currently under assessment for the RFAs (Regional Forest Agreements), and to draw inferences for the economic impacts of adoption of different forest management practices more generally throughout the RFA regions. Thirdly, to contribute relevant results to the CRAs (Comprehensive Regional Assessments) of the Upper North East (UNE) and Lower North East (LNE) NSW RFA regions.

Methods

This study examined three representative catchments in the UNE and three representative catchments in the LNE RFA regions. Within each catchment, the adopted logging scenario developed by SKM (1998) was utilised to analyse the impact of forestry activities on water quality and quantity. Each scenario was examined over three different timeframes (5, 10 and 20 years) to differentiate temporal impacts. The adopted logging scenario in each catchment was applied to a forest of current age and an old growth forest, with the logging and tree growth components of the adopted scenario being examined to understand the total impact on mean streamflow.

Utilising outputs from the Ecologically Sustainable Forest Management (ESFM) project, *"Water Quality and Quantity for the Upper and Lower North East and Southern Region"*, a relationship was determined between the change in water yield due to logging operations and the State Forest area contained within each catchment. This relationship allowed changes in water yield to be expressed in terms of changes in mean streamflow at defined gauge locations. Once this change in streamflow was determined, the economic impacts arising from this change in streamflow were estimated. Economic impacts were estimated for a variety of activities that utilise water in the downstream section of each catchment.

Key results and products

Key results in the UNE included:

- downstream water users in the Eden Creek and Terania Creek catchments deriving a slight positive economic benefit from the resultant changes in water quality and quantity;

- downstream water users in the Upper Orara River catchment deriving a significant economic benefit;
- the largest economic benefits arising when the adopted logging scenario was applied to a forest of current age, rather than an old growth forest;
- the longer the timeframe of the economic analysis, the larger the potential annual gains to downstream water users; and
- the potential for trends in impacts on mean streamflow to change when analysed over the very long-term (> 50 years).

If economic benefits are captured by agriculture, (the sector best placed to absorb marginal increases in water supply), economic benefits in each of the three catchments in the UNE will be between $0 and $205,000 per annum. Alternatively, if policy prevents this capture (e.g. NSW Water Reform Process), then incremental gains can be expected to accrue to the environment, drinking water supplies, recreation and tourism activities.

Key results in the LNE included:

- a significant negative economic impact in the Manning River catchment (due to reduced mean streamflow);
- a small positive impact in the Karuah River catchment;
- a significant positive impact in the Jilliby Jilliby Creek catchment;
- greater divergence in estimated impacts on mean streamflow across catchments; and
- therefore more variable economic impacts on downstream water users across catchments under different scenarios and timeframes.

In the LNE, if economic benefits or costs are captured by agriculture, the range of economic impacts will be between negative $39,000 and $294,000 per annum. Similarly, if policy prevents this capture, incremental gains or losses can be expected to accrue to the environment, manufacturing, drinking water supplies and recreation and tourism activities.

When interpreting the economic impacts of alternative logging scenarios, it must be remembered that economic impacts were not estimated for periods of greater than 20 years. Changes to the forest age profile in subsequent decades (> 20 years) will alter the impact that alternative logging scenarios have upon both mean streamflow and downstream water users. Therefore, the potential exists for the economic impacts estimated as part of this study to be reversed (or at least change) if analysis is undertaken over longer time periods. Such analysis was not undertaken as part of this study, but the potential for such outcomes to occur should not be ignored.

1. INTRODUCTION

1.1 OBJECTIVES OF THE STUDY

The objectives of this project are to:

- estimate the potential economic impacts of changes in water quantity and quality from forest catchments;
- focus on a selection of NSW forested catchments currently under assessment for the RFAs (Regional Forest Agreements), and to draw inferences for the economic impacts of adoption of different forest management practices more generally throughout the RFA regions; and
- contribute relevant results to the CRAs (Comprehensive Regional Assessments) of the Upper North East (UNE) and Lower North East (LNE) NSW RFA regions.

1.2 BACKGROUND

Water is an important natural resource within the UNE and LNE NSW RFA regions. The scale and nature of forestry activities within these regions may exert economic impacts on downstream activities via changes to catchment water yield and quality. Activities which are susceptible to changes in water yield and quality include the production potential of irrigated agriculture, the availability and quality of town and domestic water supplies, use for primary recreation activities and environmental stream flows.

In order to provide material to this project, an initial investigation was commissioned and was conducted by the ESFM working group. This project produced a report entitled *‘Water Quality and Quantity for the Upper and Lower North East and Southern Region’*. The aim of this investigation was to identify the scope of impacts on water quality and quantity in a selection of typical northern NSW catchments derived from a range of forest management regimes that vary in intensity.

1.3 SCOPE OF THE PROJECT

This study seeks to assess the economic impacts likely to arise from changes in water supply and quality under a range of forest management regimes in water catchments in the north-eastern NSW RFA regions. The analysis draws heavily on results for specific catchments derived from the ESFM hydrology project *(‘Water Quality and Quantity for the Upper and Lower North East and Southern Region’)*, with extrapolation to whole regions on the basis of technical principles and data also established in the ESFM project.

The scale and nature of forestry operations will influence catchment water yields and quality. In turn, these effects may induce economic impacts on downstream activities, including agriculture, manufacturing, infrastructure and drinking water supplies. Indirect impacts upon flood mitigation, recreation and tourism activities, minimum environmental flow levels and water quality also need to be taken into account.

The economic assessment conducted in this study requires outputs from the ESFM project as essential inputs. These inputs include:

- definition of catchments (based on treatment by Catchment Management Committees);
- literature review of water yield and stream flow effects on various categories of land, including forests, over time. For forests, more detailed assessment of effects of logging and plantations;
- pilot studies of a total of four representative trial catchments in the two regions, with recommendations for extrapolation across regions. The pilot studies will include details of water usage in the respective catchments; and
- a profile of water usage of both RFA regions by sub-catchment (amount of water licensed, minor and major license holders, types of products produced, rural and urban water supplies).

These outputs are available to the RFA process in the final ESFM *'Water Quality and Quantity for the Upper and Lower North East and Southern Region'* report.

Due to the time constraints under which the project was undertaken, a detailed economic study was not completed. Using existing data sources, this project sought to derive preliminary indicators of potential economic impacts. Refined estimates of economic impacts were unable to be provided within the given timeframe. Hassall & Associates completed this project for the Resource and Conservation Division in February 1999.

2. METHODOLOGY

2.1 CATCHMENTS BEING EXAMINED

The selection of catchments for the economic assessment was based upon those catchments chosen as part of the ESFM *'Water Quality and Quantity for the Upper and Lower North East and Southern Region'* project. In this project, catchments were selected using EIS tools and information on stream gauging.

Essentially, catchments were selected based on the availability of suitable information rather than representativeness[1]. The primary criterion was the availability of information to characterise the hydrology of streams both as they leave the State Forest area, and at some point downstream in agricultural areas (SKM 1998).

Within each catchment, two gauging stations were used in order to determine the impact of water yield upon streamflow. The initial gauge measuring streamflow is located immediately downstream of the forest area and is referred to in this study as the 'forest gauge'. The second gauge is located downstream of mixed landuse that occurs within the catchment. This second gauge (the 'downstream gauge') is used to monitor the impact of logging scenarios upon streamflow at a place where extractive users are utilising the resource and will be impacted by any changes in mean streamflow.

Also of note, is the catchment area and State Forest area that lies upstream of the forest gauge in each catchment. These areas are important as they are used to convert impacts on water yield into impacts on streamflow. The catchment area and State Forest area are not necessarily the same, as in some cases the area upstream of the forest gauge includes National Parks and some small amounts of agricultural activity. Corresponding areas lying upstream of the downstream gauge are also provided. The area of State Forest lying upstream of the downstream gauge is not necessarily the same as the area upstream of the forest gauge, as in some cases tributaries draining additional forest area enter into the main stream below the upstream gauge (SKM 1998).

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[1] The selection of catchments based on suitable information rather than purely as a representative sample may inherently result in some statistical bias within the study. However, given the lack of existing information for many catchments within the regions of this study, a random selection of catchments was not considered to be a viable option.

2.1.1 Upper North East

Catchments being examined in the Upper North East are listed in Table 2.A. This Table also lists the State Forest identification number(s) for the forest area contained within each catchment and the mean annual rainfall for each catchment.

Table 2.A: Selected Catchments in the Upper North East

Catchment Name	State Forest Identification Number/s	Mean Annual Rainfall (mm)
Eden Creek	343	1,240
Terania Creek	173, 3	1,830
Upper Orara River	535, 612	2,070

Source: SKM 1998

The gauge numbers for each catchment and the catchment and forest area lying upstream of each gauging station are provided in Table 2.B.

Table 2.B: Characteristics of Catchments in the Upper North East

	Downstream of Forest			Downstream of Mixed Land Use		
Catchment Name	Gauge Number	Catchment Area (km^2)	U/s Forest Area (km^2)	Gauge Number	Catchment Area (km^2)	U/s Forest Area (km^2)
Eden Creek	203018	32	19	203032	202	46
Terania Creek	203036	36	31	203022	156	37
Orara Creek	204047	19	19	204025	135	76

Source: SKM 1998

2.1.2 Lower North East

Table 2.C lists those catchments being examined in the Lower North East. Once again, identification numbers for State Forests contained within catchments are provided. Mean annual rainfall statistics for each catchment are also listed.

Table 2.C: Selected Catchments in the Lower North East

Catchment Name	State Forest Identification Number/s	Mean Annual Rainfall (mm)
Manning River	276, 977	1,090
Karuah River	280, 292, 293	1,270
Jilliby Creek	124, 281	1,250

Source: SKM 1998

The gauge number of the forest and downstream gauge for each catchment are provided in Table 2.D. Also listed, are the catchment areas and upstream forest area at each gauge within each catchment.

Table 2.D: Characteristics of Catchments in the Lower North East

Catchment Name	Downstream of Forest			Downstream of Mixed Land Use		
	Gauge Number	Catchment Area (km^2)	U/s Forest Area (km^2)	Gauge Number	Catchment Area (km^2)	U/s Forest Area (km^2)
Manning River	208002	52	40	208012	480	101
Karuah River	209001	203	158	209003	974	158
Jilliby Creek	211004	8	8	211010	92	53

Source: SKM 1998

There are limitations to the data sets available for the catchments that have been selected for this project. No account is given to individual catchment characteristics such as climate, soils, vegetation and topography. Such factors will influence the impact of alternative logging scenarios on streamflow within individual catchments. The absence of catchment specific profile data ensures the adopted modelling approach is a simplification of reality, however, given the temporal constraints of this project, estimated impacts derived under such a framework are considered to be reasonable (SKM 1998).

2.2 LOGGING CASES BEING EXAMINED

For each catchment, SKM (1998) conducted an analysis of the impacts of an adopted logging scenario on water yield. This scenario reflected a situation in which logging plus tree growth occurred. The adopted logging scenario for each catchment was based on the existing distribution of forest age and split logging activity into thinning and tree group selection (selective logging). The nominal age of trees targeted for each activity was determined and the range of forest age was studied to ascertain whether the catchment provided sufficient forest to satisfy the adopted logging scenario. The adopted scenario was intended to provide reasonable management scenarios on which to base modelling. It was not intended to pre-empt decisions related to the selection of a favoured logging scenario in each region. The adopted logging scenario for each catchment is outlined in Section 2.3.

The analysis of the impacts of the logging plus tree growth scenario in each catchment was broken into two separate components to facilitate a wider degree of understanding of the modelled impacts. These components were:

- Tree growth only; and
- Logging only.

Both of these components were derived directly from the logging plus tree growth scenario. The logging plus tree growth scenario examined the total expected yield changes due to the logging of a growing forest compared to current conditions. The tree growth only component of this scenario examined the expected yield changes due to tree growth only, that is, for the "do nothing" case in which no logging is undertaken. The logging only component, on the other hand, measured those yield changes under this scenario that are attributable solely to logging. Essentially, the logging only case represents the difference in yields between the logging plus tree growth scenario and the tree growth only case (SKM 1998).

To determine the impact of the logging plus tree growth scenario on water yield in each catchment, the impact of the scenario on forest run-off had to be converted into an impact on mean streamflow. This was achieved by multiplying the change in run-off from a unit area (as measured by depth per unit area[2] (mm)) by the area of interest. This process facilitated comparison of impacts of the adopted logging scenarios between different catchments and is discussed more fully in Section 2.5 (SKM 1998).

The impacts of the adopted logging scenario on water yields were determined for:

- current conditions, (ie the mixed-age profile of the forest as estimated for the year 1998); and
- “old growth” conditions, which assumes the forest being logged is entirely at the senescent stage of water usage.

The analysis of impacts under “old growth” conditions was carried out as a hypothetical to extend the understanding of the implications of the adopted logging plus tree growth scenario[3]. As the forest is an old growth forest, there is no “tree growth” component reflected within the impacts of the adopted logging scenario in this instance.

For our reporting purposes, the modelled adopted logging scenario developed by SKM (1998) will form the basis of the analysis of the impacts of logging on downstream water users. The two separate components of this scenario will also be examined, as will the hypothetical analysis of the impact of the adopted logging scenario when applied to an old growth forest. Therefore, the impacts of the adopted logging scenario are examined across four representative cases as part of our analysis. These cases are:

- the adopted logging scenario, when applied to a forest of current age;
- the tree growth only component of the adopted logging scenario, when applied to a forest of current age;
- the logging only component of the adopted logging scenario, when applied to a forest of current age; and
- the adopted logging scenario, when applied to an old growth forest.

It must be stressed that there is only one adopted logging scenario that is being analysed in each catchment. The four representative cases are either components of the adopted scenario, or variations in the application of the scenario (application to an old growth forest). These four cases are examined individually to enhance the understanding of the impacts of the adopted logging scenario within each catchment.

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[2] Depth per unit area is simply a measure of the change in run-off from a specified unit area of forest. It provides a measure of the impact that logging has on water yield within a specified area of forest.

[3] As the old growth analysis is carried out as a hypothetical to extend the understanding of the adopted logging plus tree growth scenario, economic impacts derived under this old growth scenario must be recognised as being limited by the underlying hypothetical nature of the old growth scenario.

2.3 ADOPTED LOGGING SCENARIOS

Table 2.E outlines the adopted logging scenarios developed by SKM (1998) for each of the catchments in the UNE and LNE. For a given period, the activity is split into thinning and group selection. The percentage of the total forest that is logged annually for each activity is shown, as is the total percentage removed over the indicated period. The nominal age of the trees targeted for each activity is also shown, with the indicative age range provided in brackets (SKM 1998).

No catchment-specific logging scenarios were provided for any of the catchments in the UNE. The adopted logging scenarios in each of these catchments were based upon the scenario provided by the Northern River Region for the modelling work undertaken by State Forests for the Rocky Creek dam catchment. This scenario should be applicable to the Terania Creek catchment, as Rocky Creek is a tributary of Terania Creek. However, it is likely to be less relevant for the Eden Creek and Upper Orara River catchments[4] (SKM 1998).

Further information regarding the development of the adopted logging scenarios is provided in the ESFM *'Water Quality and Quantity for the Upper and Lower North East and Southern RFA Regions'* report prepared by SKM (1998).

Table 2.E: Adopted Logging Scenarios for Modelling

		Thinning			Selective Logging/Group Selection		
Catchment	Period (years)	Rate (%/year)	Total Canopy Removed (%)	Age Group (years)	Rate (%/year)	Total Canopy Removed (%)	Age Group (years)
Eden Creek	17	0.59	10	25 (20-80)			
	30				0.70	21	60 (45-120)
	10	0.50	5	25 (20-40)			
Terania Creek	17	0.71	12	25 (20-60)			
	30				0.70	21	60 (45-120)
	10	0.50	5	25 (20-40)			
Upper Orara River	17	0.71	12	25 (20-70)			
	30				0.70	21	60 (45-120)
	10	0.50	5	25 (20-70)			
Manning River	15	0.99	15	30 (10-35)	0.99	15	110 (40-130)
	15	0.99	15	20 (10-25)	0.33	5	60 (30-110)
	60	0.99	60	20 (10-25)			
Karuah River	10	0.80	8	20 (10-40)	1.00	10	90 (40-140)
	10	0.80	8	20 (10-40)	1.00	10	90 (40-140)
	70	0.80	56	20 (10-40)			
Jilliby Jilliby Creek	10	0.50	5	30 (20-40)	1.00	10	100 (80-140)
	10	0.50	5	30 (20-40)	1.00	10	100 (80-140)
	70	0.50	35	25 (20-30)	1.00	70	100 (30-140)

Source: SKM (1998)

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[4] SKM (1998) points out that temporal constraints, when undertaking their project, prevented them from undertaking sensitivity analysis to test how the salient assumptions impact upon the results. Lack of information also limited the ability of sensitivity testing to be carried out. Although such analysis would have strengthened the results of the study, assumptions regarding logging scenarios and their application to catchments in the UNE are regarded as sufficient given the restrictions of this study.

2.4 INTERPRETING ECONOMIC IMPACTS - TIMEFRAMES

The economic impacts derived under each of the four cases listed in Section 2.2 are examined over three time periods; short-term (5 years), medium-term (10 years) and long-term (20 years). These time periods were chosen as being realistic measures over which to conduct an economic analysis. NSW Treasury (1997) recognises that conducting economic analysis over periods of greater than 20 to 30 years' duration is of limited value due to the impact of discounting of future costs and benefits and the difficulties involved with forecasting over long time periods.

However, an important consideration to keep in mind when reviewing the estimated economic impacts within this study are the impacts that would accrue under each case over the very long-term[5]. Whereas this economic study defined the long-term as being a period of 20 years, the impacts of logging scenarios will be quite important for several subsequent decades.

Changes to the forest age profile in subsequent decades (> 20 years) will alter the impact that a logging scenario has upon mean streamflow, and therefore on downstream water users. In some instances, trends exhibited within the 20-year economic analysis may well be reversed when measured over a substantially longer timeframe. The implications of this for downstream water users will be significant. Preliminary analysis of hydrological modelling undertaken by SKM (1998) indicates that trends may be reversed under the adopted logging scenario after 20 to 30 years have elapsed.

To illustrate this point, a series of graphs are reproduced from SKM (1998) and presented below. Although the timeframe under which the economic analysis is undertaken is limited to 20 years, it is clearly evident from these graphs that impacts on water yields (and therefore streamflow) over periods greater than 20 years can differ significantly from the estimated impacts observed and reported on in the economic analysis. When interpreting economic impacts it is important to recognise the potential for such an occurrence to arise in the very long-term.

For the following graphs, Eden Creek is chosen as a representative catchment for illustrative purposes only. Where increases in water yield are referred to, this translates to an increase in streamflow (ie the forest is using less water). On the other hand, where decreases in water yield are referred to, a decrease in streamflow is estimated (ie the forest is using more water).

The top panel of Figure 2.A provides a time series plot of the impact of the adopted logging scenario (when applied to a forest of current age) on water yield. The scenario is broken into three representative cases to reflect the tree growth only component, the logging only component and the combined logging plus tree growth scenario as modelled. The second panel of Figure 2.A provides a time series plot of the impact that the adopted logging scenario has on water yields if the logging scenario is applied to an old growth forest.

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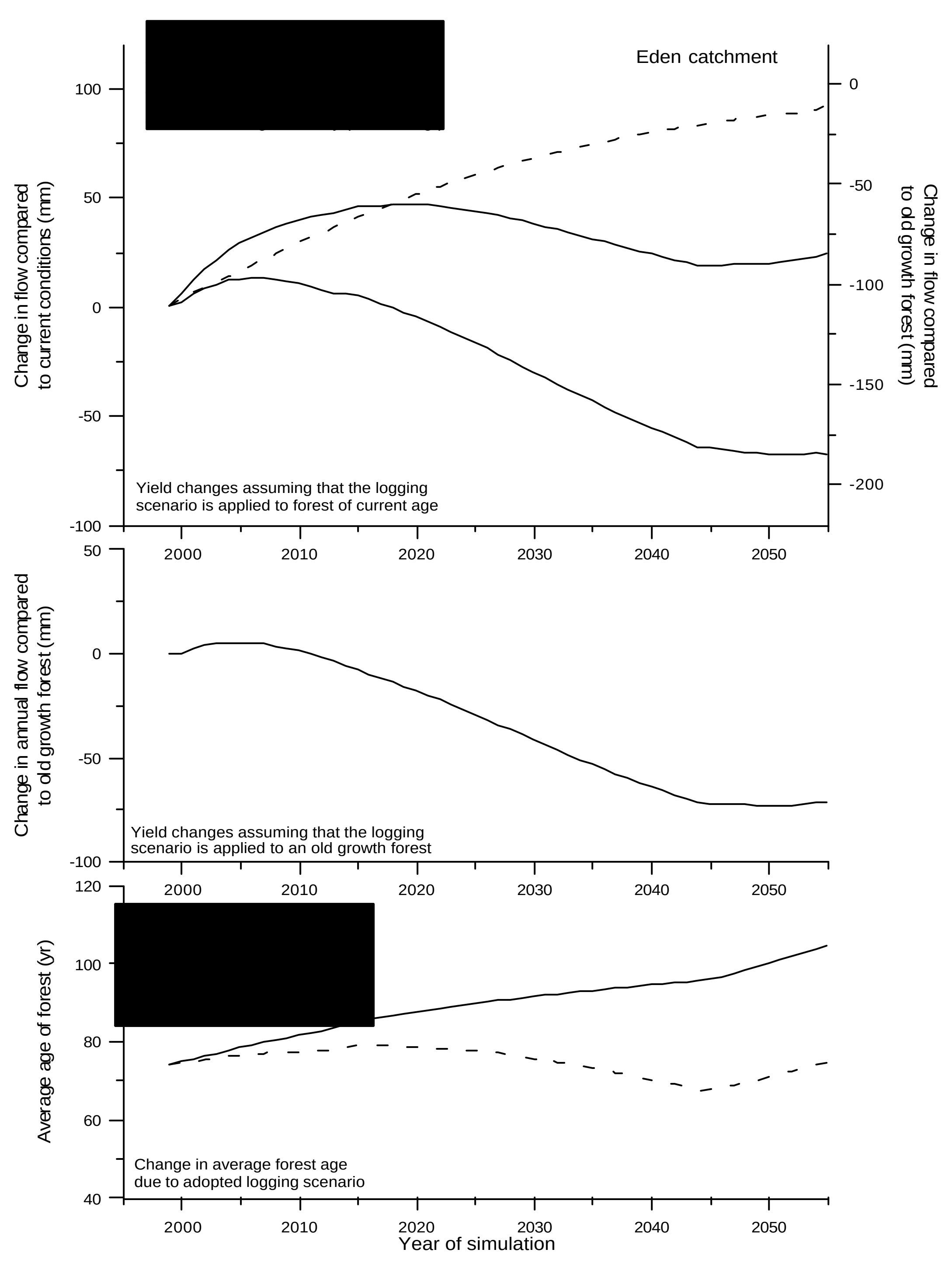
[5] For the purposes of this economic study, the very long-term is defined as a period of time greater than 50 years.

The average age of the whole forest and the average age of the harvestable area will influence the impact that the adopted logging scenario, and the components of this scenario, has upon water yields in each catchment. For the Eden Creek catchment, the third panel of Figure 2.A presents a time series plot of the average age of the forest over the period of simulation, assuming the adopted logging scenario is implemented.

Figure 2.A: The Impact of the Adopted Logging Scenario on Forest Yield – Eden Creek Catchment



Source: SKM (1998)

From the top panel in Figure 2.A it can be seen that:

- For the logging plus tree growth case, (when the adopted logging scenario is applied to a forest of current age);
    - the average annual change in water yield will exhibit increases up until approximately 2018;
    - between 2018 and approximately 2045, the average annual change in water yield will remain positive but decline in relative terms compared to the earlier period; and
    - after 2045 will exhibit increases in average annual change in water yield once again.
- For the tree growth only case;
    - in the "do nothing" case where no logging occurs, the average annual change in water yield will increase over time. This reflects the decline in water usage within the forest as the forest age profile shifts to a larger average age; and
- For the logging only case;
    - there will be increases in the average annual change in water yield in the years immediately following the adoption of the preferred scenario;
    - this trend will continue for approximately 8-10 years, after which the change in water yield will decline, becoming negative after approximately 15 years; and
    - over the very long term, this trend will continue such that average annual water yield will consistently decline.

The decline in water yields in the logging only case, in particular, over the very long-term is quite significant. The economic analysis (up to 20 years for the long-term), will not reflect the sustained decline in average water yields. Clearly, the implications of changes in the trends in impact on water yields in the very long-term relative to the long-term may have significant implications for downstream water users.

From the second panel of Figure 2, it can be seen that when the adopted logging scenario is applied to an old growth forest:

- since there is no "tree growth" component within an old growth forest, the impact on water yields will be substantially smaller (relative to the adopted scenario in a forest of current age) in the initial years following implementation of the scenario;
- as time progresses, the impact on water yields will become negative, in stark contrast to the adopted scenario as seen in panel one of Figure 2; and
- this will have important ramifications for downstream water users over the very long-term.

2.4.1 Concluding Remarks

Whereas scientific studies tend to utilise a very long-term timeframe (> 50 years) to analyse and understand potential impacts of a scenario, economic studies tend to limit their analysis to periods of time no greater than 20 to 30 years. The above graphical illustration has emphasised the importance of understanding and accounting for the differential impacts observed when estimating the impacts of logging scenarios on downstream water users under different time periods.

The potential exists, when examining the impact of adopted logging scenarios on downstream users, for impacts to vary widely and trends to reverse when the period of analysis is extended beyond a reasonable economic timeframe of 20 years.

Therefore, interpretation of the results of this study must be done realising that impacts on mean streamflow (and therefore downstream water users), over periods of greater than 20 years may differ substantially from the impacts estimated and commented upon as part of this economic study.

2.5 YIELD AND STREAM FLOW RELATIONSHIP

In order to determine the relationship between the impact of the adopted logging scenario on water yield and the associated economic impact on downstream water users, the initial requirement was to devise a relationship between water yield and streamflow.

Initially, the depth of run-off was determined for a specific unit area within the forest. This measure was defined as the depth per unit area (mm). By multiplying the depth per unit area by the total forest area contained upstream of each gauge, the impact on streamflow can be measured. That is, the impact of the adopted logging scenario (and therefore the representative cases), upon forest water yields, which is measured in millimetres, can be converted to an impact on streamflow, measured in megalitres.

For example, let's assume that the change in water yield under the adopted logging scenario is 6.1mm and the area of State Forest upstream of the forest gauge is 19km^2. The impact of this adopted scenario on mean streamflow at the forest gauge is to increase annual streamflow by 116 ML (6.1mm * 19km^2).

There are limitations to the yield-streamflow relationship. Firstly, the analysis assumes that there are no transmission losses within a stream system. In reality, mean flow as measured at a gauging station does not necessarily equate to water availability at some downstream location. Depending on the length of a stream, types of soils, access to groundwater aquifers and other factors, there may be losses as water travels throughout a system.

Secondly, as pointed out in Section 2.1, there is limited catchment specific data within the study. Although rainfall and forest areas are the main determinants of streamflow impacts, no account is taken of topography, soils and vegetation, all of which will influence downstream water availability and will be important determinants of variation between individual catchment streamflow impacts.

Finally, the hydrology analysis upon which this economic analysis is based (SKM 1998), considered only the impacts of logging scenarios on annual water yield. SKM (1998) points out that different combinations of catchment characteristics would probably affect the seasonality and frequency of flows. Changes to high and low flow regimes are quite important to take into account. In the case of agriculture, changes to the flow regime will affect the marginal value product of water (relative to it's scarcity). Failure to reflect impacts on low flow regimes will result in farmer economic risk not accurately reflecting reality. Furthermore, the use of averages (average rainfall) also ignores the sequencing of dry and wet years. Such sequencing (especially sequential dry years) will influence farmer economics, viability and finances and will have important flow-on effects on catchment communities.

The following section seeks to describe the economic impacts on various downstream activities of changes in streamflow that are derived from adopted forest logging scenarios. It must be remembered that these impacts are determined over a maximum time period of 20 years. Impacts on mean streamflow may differ significantly over longer timeframes (50 to 150 years), reflecting the changing age profile of a forest.

3. QUANTIFICATION OF ECONOMIC IMPACTS

3.1 MEASURING ECONOMIC IMPACTS

The following section seeks to define the economic ramifications for various water-dependent sectors/activities of changes in average annual streamflow due to the implementation of the adopted logging scenario. Where relevant, the economic impact of both a decline in annual average streamflow, as well as an increase in mean streamflow, are discussed.

The analysis of the economic impacts on the various activities is based on the assumption that each activity either has access to additional water which may become available given increased streamflow, or will lose some proportion of their current usage volume if streamflow declines. Regulatory mechanisms that limit the ability of a particular sector to either utilise additional flows (e.g. potentially agriculture), or protect existing allocations from any proportional decrease (e.g. potentially environmental flows), are ignored.

It must be noted that additional streamflow may only accrue to one industry where uses are exclusive. Extractive industries such as agriculture, manufacturing and drinking water supplies are deemed exclusive uses. For instance, additional water cannot accrue to both manufacturing and the environment simultaneously. The use of the additional water by the manufacturing industry precludes the use of this water by the environment.

In the following sections, economic impacts for the agricultural industry are estimated quantitatively. Due to data and other constraints, economic impacts for other sectors and activities are estimated qualitatively.

3.1.1 Agriculture

Increase in Annual Average Streamflow

An increase in streamflow will provide additional water that may be used by agriculture. One method of estimating the economic impact of additional water to agriculture is to examine the marginal value product of the resource, ie the value at which the resource could be traded.

Hassall & Associates (1998a) notes that NSW Agriculture and the Centre for Water Policy Research have derived the marginal value product of water for a number of NSW river valleys. Estimates range between $35/ML and $75/ML depending upon the production characteristics of the valley and the seasonal conditions. In this study, the marginal value product of a megalitre of water is assumed to be $45/ML[6]. An indicative method of estimating the economic impact of providing additional water to agriculture can be calculated by multiplying the marginal value product of a megalitre of water by the amount of water that is made available to the industry in excess of current allocations. This is the approach adopted within this study.

Another method by which to estimate the economic impact of additional water to agriculture is to examine the returns derived from those enterprises in which the water is used. Examining the gross margin derived from a particular enterprise will give an insight into the net returns (excluding fixed costs) derived from an irrigation-based enterprise.

Decrease in Annual Average Streamflow

A decrease in annual average streamflow may limit the annual allocation of water to irrigated agriculture. For instance, instead of irrigators receiving 100% of their entitlement, they may only be allocated some proportion of that allocation.

The effects of a reduction in water supply will include water resources being shifted out of low value enterprises into high value enterprises, improved efficiency of water use and greater structural adjustment pressures being placed on water users (Hassall & Associates 1998b).

The economic impact of a reduction in water allocation can be measured by:

- examining the returns derived from the enterprises in which production is forgone;
- calculating the value of forgone water (marginal value product multiplied by volume of water lost); or
- analysing the impact on underlying farm financial indicators such as farm business income and net farm profit.

In this study, the economic impact on irrigated agriculture of a decrease in mean streamflow is estimated by analysing the potential value of forgone water (ie the volume of water forgone multiplied by the marginal value product per megalitre).

3.1.2 Manufacturing

Increase in Annual Average Streamflow

An increase in average streamflow may result in greater impetus for manufacturing industry to expand production, or for other industries to establish a production base

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[6] Value derived assuming dominance of dairy pasture production in both RFA regions. For the purposes of this study, seasonal influences that affect the MVP of water, such as the sequencing of dry and wet years, are assumed to have no influence on the MVP of water. In reality, the relative scarcity/security of water supplies will impact upon this variable.

within the region. Measured strictly in terms of the net returns from increased production, the economic benefit derived from higher streamflow can be readily measured.

Decrease in Annual Average Streamflow

The economic impact on manufacturing of a decline in average annual streamflow will most readily be measured by a reduction in output if the industry is reliant upon water as a key input in the production chain. Depending upon the nature of the industry (high value vs low value output), the economic impact of such a decline will vary.

A decline in the amount of water available will also place pressure on manufacturing industry to increase efficiency of water use if they seek to maintain production levels. Cost efficiency savings may be able to be gained, thus offsetting some of the impacts that a reduction in water availability would otherwise cause.

3.1.3 Infrastructure

Increase in Average Annual Streamflow

An increase in average annual streamflow, if sufficiently large, may impact negatively on existing infrastructure. Roads, bridges and buildings that are in the immediate proximity of waterways may become more susceptible to the impacts of high streamflow events.

The costs involved with repairing or replacing damaged infrastructure will depend upon the scale and frequency of events that cause such damage. Small increases in streamflow are unlikely to result in identifiable cost increases.

Decrease in Annual Average Streamflow

It is assumed that a decline in average annual streamflow will have no negative economic impact on infrastructure. With a smaller volume of water flowing within waterways, it is assumed that infrastructure will be subject to less damaging stress. The total marginal positive impact is thought to be insignificant.

3.1.4 Drinking Water Supplies

Increase in Annual Average Streamflow

An increase in mean streamflow will increase the security of domestic water supply. Measuring the economic value derived from such increased security would involve the adoption of techniques such as contingent valuation. A positive willingness-to-pay for increased security of domestic water supply would only be recorded either where drinking water is in short supply or where supplies are unreliable or inconsistent. One surrogate for this benefit would be avoided costs associated with seeking alternative supplies during shortages.

An increase in average annual streamflow, if reflected in an increase in drinking water supplies, may also lead to an increase in the treatment costs associated with the provision of domestic drinking water supplies. This therefore represents a negative outcome (in terms of drinking water supplies), arising from increased mean streamflow.

Decrease in Annual Average Streamflow

Just as an increase in mean streamflow will increase the security of domestic water supply, a decrease in mean streamflow will exert some negative pressures on this security. If this pressure is significant, this could result in additional costs (trucking water, installation of rainwater tanks) in some communities.

3.1.5 Flood Mitigation

Increase in Annual Average Streamflow

Assuming an increase in streamflow causes an increase in either the extent or frequency of flood events, this will lead to an increase in the costs associated with flood mitigation.

The costs of flood mitigation will depend upon two key dimensions of the flood profile: the extent of the flood event and the duration of the flood event. Obviously, the larger the flood event that occurs, the longer the peak flow level is maintained and the longer it takes for flood levels to recede, the greater the costs associated with a flood event.

Costs involved with flood mitigation include agisting stock, purchasing alternative feed supplies, re-establishing persons and livestock at risk of being displaced by a flood event and protecting infrastructure which is susceptible to flood damage.

Decrease in Annual Average Streamflow

Assuming the flood profile and catchment hydrology is typical, a decline in average annual flow level will generally decrease the extent and likelihood of a flood event occurring, therefore resulting in a decline in the mitigative effort required to avoid flood damage. Resultant benefits, given the magnitude of the scenarios examined, are unlikely to be significant.

3.1.6 Recreation and Tourism Activities

Increase in Annual Average Streamflow

Water-based recreation activities will generally benefit from an increase in streamflow. Such water-based activities include fishing, swimming and canoeing. The scale of this benefit, as measured in economic terms, depends upon a number of factors, including the proximity of recreational activities to urban centres, the provision of substitute sites for recreational activity and the importance of recreation activities to the community (NSW EPA 1995).

Measuring the economic benefit derived from recreation activities is difficult. Some measure of the amenity value of recreation will provide an indicator of the benefit derived by individuals from having the opportunity to partake in recreation activities. However, these values are only valid if they “create” a benefit derived from recreation activity in addition to the current “stock” of benefit.

Decrease in Annual Average Streamflow

A decrease in mean streamflow will impact upon recreation activities only if they reduce the “stock” of recreational benefit. Unless this “stock” of recreational benefit is reduced, there will be no costs associated with a decrease in mean streamflow.

3.1.7 Minimum Environmental Flows

Increase in Annual Average Streamflow[7]

Measuring the economic impact on the environment from an increase in streamflow is a difficult exercise given the lack of research that has been conducted in attempting to value environmental costs and benefits.

An increase in streamflow may benefit the environment, especially in relation to the provision of environmental flows. Increases in streamflow of an ample nature may be sufficient to allow an increase in the certainty of minimum environmental streamflow being met. Indicators of the benefit derived by the environment from increased water flow include impacts upon the aquatic ecosystem, fish populations, bird habitats and the riverine environment.

Alternatively, the potential does exist for increases in mean streamflow to damage the environment. Undesirable changes to the water ecosystem may arise from more regular flushing of the river system. Habitat destruction is an example of a negative impact on the environment that may arise via the provision of increased streamflow.

Decrease in Annual Average Streamflow

A decrease in annual average streamflow is likely to have significant costs for the environment. The already stressed state of many riverine environments within NSW means that any decline in average flow levels will exacerbate conditions within already stressed environments.

Measures that can be used to examine the impact of decreased streamflow include eutrophication, turbidity, bank erosion and impacts on wetlands. As well, there are other downstream indicators of the impact of a decrease in mean streamflow. For

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[7] For the purposes of this study, it is assumed that an increase in mean streamflow will provide an economic benefit to the environment. Conversely, a decline in mean streamflow is assumed to cause economic costs to accrue to the environment. Given the underlying lack of data and the temporal constraints of the study, it was not possible to determine the absolute magnitude of benefits and costs, nor the relationship between what magnitude of change in absolute mean streamflow is required to cause resultant environmental benefits and costs to accrue.

coastal catchments, these impacts include changes in fish, prawn and oyster estuary yields.

3.1.8 Water Quality

Numerous recent studies have been done using techniques such as contingent valuation and choice modelling to determine consumer willingness to pay for improved water quality. The Centre for International Economics (1997), Morrison, Bennett and Blamey (1998), Hill (1994), Dwyer Leslie (1991) and Carlos (1991) all directed effort into determining some measure of the consumer value derived from improved water quality. Estimates of willingness to pay ranged between $20 and $170 per person (1997 dollars) depending upon the survey methods utilised and region of focus.

Undertaking a similar task to determine a quantitative consumer value for improvements in water quality in the selected catchments is beyond the scope of this study. Given data limitations, a qualitative approach provides a more realistic method of determining the impacts of changes in mean streamflow on water quality.

Turbidity provides a measure by which to examine the impact of the adopted logging scenario on water quality. An increase in the amount of suspended solids within a stream may result in a decline in water quality and therefore an increase in environmental costs. Some indicators of increased costs include:

- loss of stream environmental health;
- increase in blue-green algae outbreaks; and
- additional water treatment costs.

The impact of logging scenarios, (as modelled by SKM (1998)), on water quality are, where possible, quantified and described within each of the catchment profiles in Section 4.

3.2 INDIRECT ECONOMIC IMPACTS

The analysis within Section 3.1 has concentrated on examining methods for estimating the direct economic impacts associated with an increase and a decrease in mean streamflow. In addition to any direct impacts that are incurred by a particular water use activity, there will be indirect (flow-on effects) which are also induced. These impacts will include flow-on effects upon income, expenditure and employment within the local community. Such secondary impacts occur across all industries and are important components to be examined when undertaking an extensive economic study. However, for the purposes of this study, such impacts are not analysed.

4. UPPER NORTH EAST

This section examines the economic impacts estimated under each of the representative cases for the three catchments that are used as case studies in the UNE. A profile of the wider river basin to which the catchment belongs is provided, as is an overview of current water usage within the actual catchment. The impact of the adopted logging scenario is assessed by analysing the impacts on mean streamflow estimated under the four representative cases outlined in Section 2.2. Subsequently, the economic impacts arising due to changes in mean streamflow are ascertained for various water-based activities and industries.

4.1 EDEN CREEK

4.1.1 Catchment Profile

Eden Creek flows into the Richmond River above Casino and is therefore part of the Richmond River Basin. The Richmond River catchment covers 6,864 sq km. The NSW Environmental Protection Agency (EPA) (1997) state that in inland regions within this basin, including the Eden Creek catchment, dairying, beef and timber industries are the dominant agricultural enterprises. Hassall & Associates (1996) indicate that irrigated agriculture extractions in the Richmond River valley also include intensive piggeries and horticulture.

Tourism is an important regional industry within the basin. Major centres within the Richmond River Basin near the Eden Creek catchment include Casino and Kyogle (Hassall & Associates 1996).

4.1.2 Water Usage Profile

The most comprehensive estimate of the water usage profile in the Eden Creek catchment is derived from Department of Land and Water Conservation (DLWC) data collected as part of the Stressed Rivers Program. This data was specifically collated for the purpose of deriving hydrological indicators of rivers. For the purposes of this study, the data is intended only as an indicative estimate of water usage patterns in the Eden Creek catchment.

Table 4.A provides estimates of water usage in this catchment for those months in which irrigated agriculture utilises water extractions. Estimated usage is broken into irrigation usage and other usage, which includes other industries and towns.

Table 4.A: Estimated Water Usage – Eden Creek

Current Development – Estimated usages (ML)							
Industry	January	August	September	October	November	December	**Total[1]**
Irrigation	38.34	29.49	38.34	38.34	56.03	38.34	**239**
Other	0.15	0.15	0.15	0.15	0.23	0.15	**1**

Source: DLWC 1998a

[1] Hassall & Associates estimate. Estimates of total usage refer only to those months in which irrigation extractions take place.

Table 4.A shows that irrigated agriculture is the predominant water user in the Eden Creek catchment. The small usage estimated for other water users indicates that there is only very small domestic and industrial water demand within the catchment.

4.1.3 Eden Creek Mean Annual Streamflow

Average annual streamflow in the Eden Creek catchment as measured at both the forest gauge (203018) and the downstream gauge (203032) is provided in Table 4.B.

Table 4.B: Mean Annual Streamflow – Eden Creek

Catchment Name	Gauging Station	Mean Annual Flow (ML)
Eden Creek	203018 203032	17,500 80,000

Source: SKM 1998

4.1.4 Water Quality in Eden Creek

In 1996, RACAC commissioned the NSW EPA to conduct a water quality assessment study in the Richmond River Basin. These assessments indicated that water quality in the Richmond River basin was generally poor under low flow conditions. Criteria related to aquatic ecosystems, potable water and primary contact recreation were all deemed poor. For other activities, such as secondary recreation contact uses and irrigation and livestock use, quality was classed as good or fair (NSW EPA 1997).

More recently, DLWC (1998b) categorised Eden Creek in terms of stress classifications. These classifications are summarised in Table 4.C.

Table 4.C: Environmental Stress Ratings – Eden Creek

Category	Stress Rating
Overall Stress Classification	Medium Environmental Stress[1]
Full Development Stress Classification	Medium Environmental Stress[2]
Hydrology Stress Rating	Low
Environmental Stress Rating	Medium

Source: DLWC 1998b

[1] assumes low extractions

[2] assumes high extractions

In addition, as part of the *Stressed Rivers Assessment Report* (DLWC 1998b), both NSW Fisheries and the National Parks and Wildlife Service (NPWS) have identified Eden Creek as having a high conservation value.

In terms of this study, water quality in the Eden Creek catchment will be most dependent upon the impact of the adopted logging scenario upon sediment concentration. The estimated range of sediment concentration at both the forest and downstream gauge under a logging and no logging ("do nothing") scenario was provided within the SKM (1998) study. Table 4.D reproduces these ranges for the Eden Creek catchment.

Table 4.D: Estimated Range of Sediment Concentration – Eden Creek

Catchment	Forest Gauge		Downstream Gauge	
	No Logging (mg/L)	Logging (mg/L)	No Logging (mg/L)	Logging (mg/L)
Eden Creek	0.3 – 0.5	0.3 – 0.6	0.1 - 0.3	0.2 – 0.3

Source: SKM 1998

It is important to note that these concentrations represent the sediment load coming from the forest, thereby ignoring the sediment loads coming from agricultural and other industries within the catchment (SKM 1998).

To gain some perspective on the impact of logging activities on water quality, it is necessary to examine the difference in sediment load estimated under each scenario at each gauge. Examining changes in sediment load between the logging and no logging scenario is more important than the absolute magnitude of sediment load, as it allows the impact of logging activities on water quality to be clearly understood. As can be seen, there is very little difference in the estimated sediment load between the logging and no logging scenario. This would suggest that the impact of the adopted logging scenario on sediment concentration is minimal.

However, SKM (1998) acknowledges that applying these estimates within a downstream context is difficult due to the lack of information on total sediment loads.

Turbidity is a common measure used within the field to monitor water quality, however this is not a direct measure of sedimentation. Despite this, SKM (1998) note that turbidity data can be used to make qualitative estimates of likely sediment concentrations. Examining turbidity data collected on the Eden River through the DLWC Key Sites Program reveals that the median reading for turbidity is 5.0 NTU (Nephelometric Turbidity Units). Given guidelines suggest turbidity of less than 5 NTU for drinking water, the small relative increase in sediment loads estimated to occur due to logging suggest that the adopted logging scenario will not significantly alter turbidity ratings nor, therefore, water quality in the Eden Creek catchment (SKM 1998).

4.1.5 Impacts of the Adopted Logging Scenario

To analyse the impact of the adopted logging scenario on mean streamflow in the Eden Creek catchment over time, the four representative cases are utilised. Recall that these cases consist of:

- the adopted logging scenario, when applied to a forest of current age;
- the tree growth only component of the adopted logging scenario, when applied to a forest of current age;
- the logging only component of the adopted logging scenario, when applied to a forest of current age; and
- the adopted logging scenario, when applied to an old growth forest.

Therefore, only one adopted logging scenario is being examined in this analysis. The use of four representative cases is simply to increase the understanding of the impacts of this scenario if particular parameters of the scenario are either altered (application to old growth forests) or focussed upon (analyse the tree growth or logging component of the adopted logging scenario individually).

Based on the yield and area data provided by SKM (1998), the average annual impact on mean streamflow at the two gauging stations in the Eden Creek catchment was derived for each representative case by time period. Table 4.E lists the average annual impact on streamflow at the forest gauge.

Table 4.E: Average Annual Impact on Streamflow – Forest Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth Scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**1.2%**	0.7%	0.6%	0.2%
Medium Term (10 yrs)	**2.3%**	1.4%	1.0%	0.4%
Long Term (20 yrs)	**3.5%**	2.7%	0.8%	-0.1%

From Table 4.E, it can be seen that under nearly all representative cases over varying timeframes, the impact on average annual streamflow is positive. The adopted logging scenario reflects increases in mean streamflow of up to 3.5% over the long-term. If no logging activities were carried out (tree growth only component) much of this increase in mean streamflow would occur regardless. Therefore the actual positive impact of the logging activities under current conditions are not particularly substantial. If the adopted logging scenario was implemented in an old growth forest, the positive impact on mean streamflow would be less substantial, declining in the long-run.

The magnitudes of impacts as measured at the forest gauge are not exceptionally large under all representative cases. Further, it is expected that impacts at the downstream gauge would be even less than those estimated at the forest gauge, as the flows measured at the downstream gauge are larger due to the impact of tributaries joining Eden Creek downstream of the forest gauge.

Table 4.F lists the impacts of the adopted logging scenario on average annual streamflow as measured at the downstream gauge. In order to determine the economic impacts of logging scenarios on downstream water users, it is the impact on average annual streamflow at this gauge that must be examined.

Table 4.F: Average Annual Impact on Streamflow – Downstream Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth Scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**0.6%**	0.4%	0.3%	0.1%
Medium Term (10 yrs)	**1.2%**	0.7%	0.5%	0.2%
Long Term (20 yrs)	**1.9%**	1.4%	0.4%	-0.1%

In the short and medium term, average annual streamflow will increase slightly under the adopted logging plus tree growth scenario. In the long-term, average annual streamflow will increase by less than 2%. The logging only component (current conditions) of this increase is relatively small. If the adopted logging scenario is applied to an old growth forest, the impacts on mean streamflow will be even more marginal.

Furthermore, a decline in the impact on mean streamflow between the medium-term and the long-term is estimated under the logging only case (current conditions) and the logging scenario when applied to an old growth forest. This suggests that over the very long-term, logging activities, when analysed separately from tree growth influences, will produce a negative impact on mean streamflow. Although an analysis of impacts in the very long-term does not form part of this economic analysis, these impacts should be kept in mind when reviewing economic impacts.

The magnitude of the impacts estimated in Table 4.F, (a maximum of 1.9% in the long-term), suggest that the economic impacts derived under these scenarios will not be large. An examination of the potential economic impacts arising from the influence of the adopted logging scenario on downstream water users is provided in the following section.

4.1.6 Potential Economic Impacts

Given the small scale of the modelled increases in mean streamflow that are estimated under the adopted logging scenario over the varying time periods, the economic impact of the adopted logging scenario on downstream water users is not significant. Since an increase in mean streamflow is being estimated when the adopted logging scenario is applied to a forest of current age, downstream water users will derive an economic benefit from this additional water.

The industry/activity in which this additional water is utilised will determine the scale of the economic benefit derived by downstream water users. If the water is provided to the environment, different types of benefits will accrue (mainly non-monetary) to those benefits which would arise if the water was provided to agriculture (mainly monetary). As stated earlier, this economic analysis assumes that each water user has the ability to access additional water (assuming water users are not mutually exclusive activities). Thus, potential economic impacts are determined on the basis that there are no policy restrictions limiting water use within industries (e.g. NSW Water Reform Process), or directing additional streamflow to any particular activity (e.g. the environment).

Estimates of potential economic impact were derived assuming that additional water was allocated to either agriculture or to other users. Adoption of this method ensured double-counting of economic impacts did not occur, by recognising that additional water can only be utilised by one particular sector (e.g. agriculture or the environment). Preliminary quantitative estimates were deduced for agriculture whilst a qualitative assessment procedure was adopted in determining the economic impacts on other downstream water users.

Table 4.G provides an indicative estimate of the potential economic impact of the adopted logging scenario on sectors that are dependent upon water resources in the Eden Creek catchment. For agriculture, a range of estimates is provided. The lower limit of this range reflects the benefit or cost if the adopted scenario is applied to an old growth forest, whilst the upper limit of this range reflects the benefit derived if the adopted logging scenario is applied to a forest of current age. For other industries/activities, listed impacts assume additional water accrues only to activities that are not mutually exclusive. For instance, use of water by the manufacturing industry precludes use by the environment. On the other hand economic impacts may be incurred simultaneously from the same volume of water for non-exclusive activities such as environmental flows and water quality.

Table 4.G: Potential Economic Impacts – Eden Creek

	Sector	**Potential Economic Impact**
EITHER	Agriculture[1]	\$4,000 - \$23,000 (ST) \$7,000 - \$44,000 (MT) -\$2,000 - \$67,000 (LT)
OR[2]	Manufacturing	Not Significant
	Infrastructure	Nil
	Drinking Water Supplies	Small Positive
	Flood Mitigation	Not Significant
	Recreation & Tourism Activities	Small Positive
	Minimum Environmental Flows	Small Positive
	Water Quality	Small Negative/Insignificant

1. ST = Short Term (5 yrs), MT = Medium Term (10 yrs), LT = Long Term (20 yrs). All estimates are average annual impacts.
2. Impacts on other industries/activities (excluding agriculture) may be mutually exclusive. Potential economic impacts should therefore not be summed.

Therefore, the annual economic impact of the adopted logging scenario on downstream water users in the Eden Creek catchment is estimated to be slight and positive. If additional water is allocated to agriculture, the annual economic benefit derived will be no greater than \$67,000 in the long-term. To place this in perspective, the Department of Water Resources (1994) estimated the gross value of agricultural production on the North Coast at \$511 million (1991/92 dollars). Allocation of additional water to alternative activities will result in a small positive impact being derived if this allocation is made to either recreation and tourism activities, town drinking water supplies or the environment.

Since the modelled changes to streamflow are quite small, the benefit derived from this increased availability of water is also small. The greatest economic benefit is derived when the greatest increase in mean streamflow is estimated. If the adopted logging scenario is applied to an old growth forest rather than to a forest of current age the positive economic impact will be smaller in the short and medium-term and will be negative in the long-term.

The economic analysis also shows that, generally, the longer the timeframe being examined, the greater the increase in mean streamflow and therefore, the greater the economic benefit derived by downstream water users. Although this is true for the results illustrated in Table 4.F, this statement needs to be qualified. Recall that impacts in the very long-term may well differ substantially from those impacts estimated to occur over the long-term (refer to Section 2.4). Therefore, the potential exists for mean streamflow to decline in the very long-term, especially if the logging scenario is applied to an old growth forest. The implications of this reduced mean streamflow for downstream water users in the very long-term should be considered when analysing the impacts of the adopted logging scenario (despite the fact that these very long-term impacts are not formally qualified/quantified as part of this economic study).

4.2 TERANIA CREEK

4.2.1 Catchment Profile

Terania Creek flows into the Wilsons River at Lismore. It is part of the Richmond River Basin. Section 4.1.1 outlined some of the major characteristics of this river basin.

4.2.2 Water Usage Profile

The most comprehensive estimate of the water usage profile in the Terania Creek catchment is derived from DLWC data (1998a) collected as part of the Stressed Rivers Program. This data was specifically collated for the purpose of deriving hydrological indicators of rivers. For the purposes of this study, the data is intended as an indicative estimate of water usage patterns in the Terania Creek catchment.

Table 4.H provides estimates of water usage in this catchment for those months in which irrigated agriculture utilises water extractions. Estimated usage is broken into irrigation usage and other usage, which includes other industries and towns.

Table 4.H: Estimated Water Usage – Terania Creek

	Current Development - Estimated usages (ML)						
Industry	January	August	September	October	November	December	**Total[1]**
Irrigation	165.31	127.16	165.31	165.31	241.60	165.31	**1030**
Other	6.55	5.04	6.55	6.55	9.57	6.55	**41**

Source: DLWC 1998a

[1] Hassall & Associates estimate. Estimates of total usage refer only to those months in which irrigation extractions take place.

Water usage in the Terania Creek catchment is significantly greater than water usage in the Eden Creek catchment. Also, in the Terania Creek catchment other water users account for a proportionally larger amount of total water usage than in the Eden Creek catchment.

4.2.3 Terania Creek Mean Annual Streamflow

Average annual streamflow in the Terania Creek catchment as measured at both the forest gauge (203036) and the downstream gauge (203022) is provided in Table 4.I.

Table 4.I: Mean Annual Streamflow – Terania Creek

Catchment Name	Gauging Station	Mean Annual Flow (ML)
Terania Creek	203036 203022	30,000 146,000

Source: SKM 1998

4.2.4 Water Quality in Terania Creek

Being part of the Richmond River basin, the environmental indicators discussed in Section 4.1.4 also apply to the Terania Creek catchment. As part of the *Stressed Rivers Assessment Report* (DLWC 1998b), Terania Creek has been identified by both NSW Fisheries and NPWS as having a high conservation value.

Utilising DLWC (1998b), the categories estimated for Terania Creek in terms of stress classifications are summarised in Table 4.J.

Table 4.J: Environmental Stress Ratings – Terania Creek

Category	Stress Rating
Overall Stress Classification	Medium Environmental Stress[1]
Full Development Stress Classification	Medium Environmental Stress[2]
Hydrology Stress Rating	Low
Environmental Stress Rating	Medium

Source: DLWC 1998b

[1] assumes low extractions

[2] assumes high extractions

In terms of this study, water quality in the Terania Creek catchment will be most dependent upon the impact of the adopted logging scenario on sediment concentration. The estimated range of sediment concentration at both the forest and downstream gauge under a logging and no logging ("do nothing") scenario was provided within the SKM (1998) study. Table 4.K reproduces these ranges for the Terania Creek catchment.

Table 4.K: Estimated Range of Sediment Concentration – Terania Creek

Catchment	Forest Gauge		Downstream Gauge	
	No Logging (mg/L)	Logging (mg/L)	No Logging (mg/L)	Logging (mg/L)
Terania Creek	1.3 – 2.7	1.5 – 3.0	0.3 - 0.7	0.4 – 0.7

Source: SKM 1998

As can be seen, there is some variation in sediment load between the logging and no logging scenario when measured at the forest gauge. However, there is very little difference in the estimated sediment load under both the logging and no logging scenario when measured at the downstream gauge. Also, sediment load at the downstream gauge is lower than that measured at the forest gauge. The logical cause of this is the vast array of tributaries which flow into Terania Creek downstream of the forest gauge acting to dilute the sediment concentration level by the time flows reach the downstream gauge[8].

There is no corresponding turbidity data available for Terania Creek as was available for Eden Creek. However, given the marginal difference between sediment concentration under the logging and no logging scenarios at the downstream gauge, it is concluded that the impact of logging activities on water quality, as measured at the downstream gauge, is marginal.

4.2.5 Impacts of the Adopted Logging Scenario

Once again, the components and variations of the adopted logging scenario are utilised to examine the impact of the adopted scenario on downstream water users in the Terania Creek catchment. Therefore, the impact on mean streamflow at both the forest gauge and the downstream gauge are recorded across all four representative cases.

Based on the yield and area data provided by SKM (1998), the average annual impact on mean streamflow at two gauging stations in the Terania Creek catchment was derived for each representative case by time period. Table 4.L lists the average annual impact on streamflow at the forest gauge.

Table 4.L: Average Annual Impact on Streamflow – Forest Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**2.3%**	1.1%	1.2%	0.4%
Medium Term (10 yrs)	**5.0%**	2.7%	2.3%	0.6%
Long Term (20 yrs)	**8.9%**	5.9%	3.0%	-0.2%

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[8] Recall that all concentrations in Table 4.K represent sediment load coming from the forest only, thereby ignoring sediment loads coming from agriculture and other industries within the catchment.

Table 4.L shows that the impacts of the adopted logging scenario in the Terania Creek catchment are significantly greater than those witnessed under the equivalent cases in the Eden Creek catchment. The long-term impact on mean streamflow under the adopted logging scenario is 8.9%. The component of this impact that can be attributed to logging activities in particular, is approximately one third in the long term. However, if the adopted logging scenario was applied to an old growth forest, the specific impacts attributable to the logging activities is substantially less, with a decline in mean streamflow predicted over the long-term.

When the adopted logging scenario is applied to a forest of current age, the positive change in mean annual streamflow increases at a rapid rate between the short and medium-term. This rate slows (but still increases) from the medium-term to the long-term.

Changes to mean annual streamflow at the downstream gauge are provided within Table 4.M. Once again, the impacts at the downstream gauge are utilised to derive the economic impact of the adopted logging scenario upon downstream water users.

Table 4.M: Average Annual Impact on Streamflow – Downstream Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**0.6%**	0.3%	0.3%	0.1%
Medium Term (10 yrs)	**1.2%**	0.7%	0.6%	0.1%
Long Term (20 yrs)	**2.2%**	1.4%	0.7%	0.0%

There is a significant decline in the impact of the adopted logging scenario on mean streamflow at the downstream gauge compared with estimated impacts as measured at the forest gauge within the Terania Creek catchment. The reason for this is that there are several tributaries which enter Terania Creek between the forest gauge and the downstream gauge which increase streamflow, thereby reducing the impact of the adopted logging scenario when compared to this greater volume of streamflow.

Table 4.M illustrates that at the downstream gauge there will be no decline in mean streamflow in the Terania Creek catchment over the three time periods regardless of whether the adopted logging scenario is applied to a forest of current age or an old growth forest. Although both the tree growth only component and logging only component of the adopted logging scenario are approximately equivalent in the short and medium-term, in the long-term the tree growth component accounts for almost two thirds of the increase in mean streamflow estimated for the adopted logging scenario.

Once again, the small magnitude of estimated increases in mean streamflow under the adopted logging scenario suggests that the economic impacts derived from this changed streamflow will not be particularly large. An examination of the potential economic impact of the adopted logging scenario on downstream water users is provided in the following section.

4.2.6 Potential Economic Impacts

The average annual impact on streamflow, as measured at the downstream gauge in Terania Creek, is quite similar to those impacts estimated for Eden Creek. In the long-term, impacts in the Terania Creek catchment are slightly larger than those estimated in the Eden Creek catchment, although they are still of the same order of magnitude. The increase in mean streamflow that is estimated when the adopted logging scenario is applied to a forest of current age will result in a small positive economic benefit accruing to downstream water users.

Similar to Section 4.1.6, indicative estimates of economic impact were derived assuming that additional water was allocated to either agriculture or was allocated to other activities (assuming these uses were not mutually exclusive). Table 4.N summarises these indicative potential economic impacts. For agriculture, a range of estimates is produced to reflect variation in costs and benefits across the four representative cases. The upper limit of this range reflects outcomes when the adopted logging scenario is applied to a forest of current age, whilst the lower limit estimates accrue when analysing the impacts when the logging scenario is applied to an old growth forest.

Table 4.N: Potential Economic Impacts – Terania Creek

	Sector	**Potential Economic Impact**
EITHER	Agriculture	\$3,000 - \$20,000 (ST) \$5,000 - \$44,000 (MT) -\$2,000 - \$78,000 (LT)
OR[2]	Manufacturing	Small Positive
	Infrastructure	Nil
	Drinking Water Supplies	Small Positive
	Flood Mitigation	Not significant
	Recreation & Tourism Activities	Small Positive
	Minimum Environmental Flows	Small Positive
	Water Quality	Small Negative/Insignificant

1. ST = Short Term (5 yrs), MT = Medium Term (10 yrs), LT = Long Term (20 yrs). All estimates are average annual impacts.
2. Impacts on other industries/activities (excluding agriculture) may be mutually exclusive. Potential economic impacts should therefore not be summed.

The annual economic impact of the adopted logging scenario on downstream water users in Terania Creek is estimated to be slight and positive. If water is allocated to agriculture, the annual economic benefit is assumed to be no greater than \$78,000 under any timeframe[9]. If water is allocated to other activities, a small positive impact is also estimated for most uses. Benefits will accrue if additional water is allocated to the environment, town water supplies, manufacturing or recreation and tourism activities.

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[9] Recall that the Department of Water Resources (1994) estimated the gross value of agricultural production on the North Coast at \$511 million (1991/92 dollars).

These outcomes are consistent with the impacts estimated within the Eden Creek catchment. This reflects the similar landuse patterns and similar impacts on mean streamflow estimated under the adopted logging scenario within each catchment[10].

Furthermore, similar to the Eden Creek catchment, the economic benefit derived from increased streamflow increases as the timeframe being examined increases[11]. The largest economic benefit will accrue to downstream water users if the adopted logging scenario is applied to a forest of current age rather than an old growth forest. In general, over the timeframe of the economic analysis, the magnitude of economic benefits accruing to downstream water users will correlate to the size of the estimated increase in mean streamflow.

4.3 UPPER ORARA RIVER

4.3.1 Catchment Profile

The Upper Orara River catchment lies within the Clarence River Basin. Major centres within the Clarence River Basin include Grafton, Yamba and Dorrigo. The dominant irrigated agriculture activities in this basin are stone fruit and blueberry production. Smallholder farmlots dominate landuse with enterprises as diverse as goats, small orchards, emus, horticultural crops and horses found within and around the Upper Orara River catchment (Hassall & Associates 1996).

4.3.2 Water Usage Profile

The most comprehensive estimate of the water usage profile in the Upper Orara River catchment is derived from the DLWC Stressed Rivers Program. Table 4.O provides estimates of water usage in this catchment for those months in which irrigated agriculture utilises water extractions. Estimated usage is broken into irrigation usage and other usage, which includes other industries and towns.

Table 4.O: Estimated Water Usage – Upper Orara River

	Current Development – Estimated usages (ML)						
Industry	January	August	September	October	November	December	**Total[1]**
Irrigation	116.39	54.32	69.84	100.88	147.43	108.64	**598**
Other	0.17	0.08	0.10	0.15	0.21	0.16	**1**

Source: DLWC 1998a

[1] Hassall & Associates estimate. Estimates of total usage refer only to those months in which irrigation extractions take place.

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[10] Similarity of outcomes between catchments will also reflect the absence of significant catchment-specific variables such as topography, transmission losses, soils and vegetation. Inclusion of these unique catchment characteristics within the underlying modelling would influence expected changes to streamflow, leading to greater variation in results across catchments than is otherwise witnessed.

[11] Similar to the discussion in Section 4.1.6, this statement holds for the time periods being analysed as part of the economic analysis. Impacts on mean streamflow in subsequent periods, (> 20 years), may well differ from those estimated above. Consideration should be given to the potential for such a situation to arise and the implications this has for downstream water users.

There is significant variation in water usage in the Upper Orara River between seasons. Total catchment usage falls between that which is estimated for the Eden Creek catchment and estimated usage for the Terania Creek catchment. Of note, is the small proportion that other industries account for in total water usage. This indicates that there is limited domestic and industrial demand for water within this catchment.

4.3.3 Orara River Mean Annual Streamflow

Average annual streamflow in the Orara River catchment as measured at both the forest gauge (204047) and the downstream gauge (204025) is provided in Table 4.P.

Table 4.P Mean Annual Streamflow – Upper Orara River

Catchment Name	Gauging Station	Mean Annual Flow (ML)
Upper Orara River	204047 204025	35,000 126,000

Source: SKM 1998

4.3.4 Water Quality in Upper Orara River

As part of the *Stressed Rivers Assessment Report* (DLWC 1998b), the Upper Orara River has been identified by both NSW Fisheries and NPWS as having conservation value. This conservation value was determined at the same time that stress classifications were determined for this catchment. Table 4.Q lists the stress classifications that were determined for the Upper Orara River as part of this process.

Table 4.Q: Environmental Stress Ratings – Upper Orara River

Category	Stress Rating
Overall Stress Classification	Medium Environmental Stress[1]
Full Development Stress Classification	Medium Environmental Stress[2]
Hydrology Stress Rating	Medium
Environmental Stress Rating	Medium

Source: DLWC 1998b

[1] assumes low extractions

[2] assumes high extractions

Once again, water quality in the Upper Orara River will be extremely dependent upon the impact of the adopted logging scenario on sediment concentration. The estimated range of sediment concentration at both the forest and downstream gauge under a logging and no logging scenario was provided within the SKM (1998) study. Table 4.R reproduces these ranges for the Upper Orara River catchment.

Table 4.R: Estimated Range of Sediment Concentration – Upper Orara River

Catchment	Forest Gauge		Downstream Gauge	
	No Logging (mg/L)	Logging (mg/L)	No Logging (mg/L)	Logging (mg/L)
Upper Orara River	0.4 – 0.9	0.5 – 1.0	0.5 – 1.0	0.6 –1.1

Source: SKM 1998

Of note in Table 4.R is the fact that, unlike the other two UNE catchments, sediment concentration at the downstream gauge is greater than those levels recorded at the forest gauge. The high proportion of the catchment that is forested is the logical cause of this occurrence. Despite this, there is only slight variation in sediment load between the logging and no logging scenario when measured at both gauges. This indicates that logging activities do not significantly alter sediment concentration within the Upper Orara River catchment[12].

Utilising turbidity data collected on the Orara River at Glenreagh as part of the DLWC Key Sites Program, it can be seen that the median turbidity reading recorded was 2.1 NTU (SKM 1998). A reading of less than 5 NTU is considered 'good' for drinking water (SKM 1998). Thus, it can be argued that the marginal increase in sediment load estimated under the logging scenario will not cause water quality in the Upper Orara River catchment to decline to an extent that the drinking water supply is placed in jeopardy.

4.3.5 Impacts of the Adopted Logging Scenario

Based on the yield and area data provided by SKM (1998), the average annual impact on streamflow at two gauging stations in the Upper Orara River catchment was derived for the adopted logging scenario by time period. As with the other two catchments in the UNE, the impacts of the adopted logging scenario are reported by breaking the adopted scenario into four representative cases. Table 4.S lists the average annual impact on mean streamflow at the forest gauge.

Table 4.S: Average Annual Impact on Streamflow – Forest Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**1.4%**	0.7%	0.7%	0.2%
Medium Term (10 yrs)	**3.0%**	1.6%	1.4%	0.4%
Long Term (20 yrs)	**5.1%**	3.4%	1.7%	-0.1%

Table 4.S shows that the impacts of the adopted logging scenario in the Upper Orara River catchment are larger than those impacts estimated for the Eden Creek catchment, yet smaller than the estimated impacts in the Terania Creek catchment. Once again, applying the adopted logging scenario to an old growth forest produces more marginal impacts on mean streamflow than if the adopted scenario is applied to a forest of current age. If the adopted scenario is applied to a forest of current age, in the short and medium-term, both the tree growth component and the logging component produce similar impacts. In the long-term, however, the tree growth only component accounts

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[12] Recall that all concentrations in Table 4.R represent sediment load coming from the forest only, thereby ignoring sediment loads coming from agriculture and other industries within the catchment.

for a larger proportion of the total impact caused by the adopted logging scenario than the logging component.

To measure the impact of the adopted logging scenario on downstream users, the impact of the scenario at the downstream gauge must be measured. The average annual impact on mean streamflow at the downstream gauge under the adopted logging scenario is presented in Table 4.T.

Table 4.T: Average Annual Impact on Streamflow – Downstream Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**1.5%**	0.8%	0.8%	0.2%
Medium Term (10 yrs)	**3.3%**	1.7%	1.6%	0.4%
Long Term (20 yrs)	**5.7%**	3.8%	1.9%	-0.1%

The most surprising feature of these results, in light of the results for the Eden Creek and Terania Creek catchments, is that at the downstream gauge in the Upper Orara River catchment, impacts on mean streamflow are larger than those recorded at the forest gauge. The reason that estimated impacts are greater at the downstream gauge in this catchment is due to the fact that a large proportion of the catchment, as measured at the downstream gauge, is forested (SKM 1998).

Within the Upper Orara River catchment, trends in estimates of impact on annual average streamflow across timeframes follow those trends exhibited in previous catchments. An examination of the potential economic impacts on downstream water users arising due to the adopted logging scenario is provided in the following section.

4.3.6 Potential Economic Impacts

In the Upper Orara River catchment, the estimated impacts on streamflow under each of the four representative cases and across alternative timeframes are, once again, all positive apart from the long-term when the logging scenario is applied to an old growth forest. Furthermore, impacts in this catchment are greater than those estimated in the other two UNE regions, thereby suggesting larger economic impacts will be experienced by downstream water users in the Upper Orara River catchment than water users in either of the other two UNE catchments.

Indicative quantitative and qualitative estimates of potential economic impacts for various water users in the Upper Orara River catchment are provided in Table 4.U. The boundaries of the range of impacts estimated for agriculture are defined as they were in previous UNE catchments.

Table 4.U: Potential Economic Impacts – Upper Orara River

	Sector	**Potential Economic Impact**
EITHER	Agriculture	$8,000 - $55,000 (ST) $14,000 - $118,000 (MT) $-4,000 - $205,000 (LT)
OR[2]	Manufacturing	Not significant
	Infrastructure	Slight Negative
	Drinking Water Supplies	Slight Positive
	Flood Mitigation	Slight Negative
	Recreation & Tourism Activities	Positive
	Minimum Environmental Flows	Positive
	Water Quality	Small Negative/Insignificant

1. ST = Short Term (5 yrs), MT = Medium Term (10 yrs), LT = Long Term (20 yrs). All estimates are average annual impacts.
2. Impacts on other industries/activities (excluding agriculture) may be mutually exclusive. Potential economic impacts should therefore not be summed.

Table 4.U shows that larger economic gains and losses are estimated for different water use activities in the Upper Orara River catchment than in the other two UNE catchments. If water is allocated to agriculture, the maximum annual economic benefit that can be derived is in excess of $200,000. If, however, water is allocated to other activities, there will potentially be either positive or negative impacts, or both, depending upon where the additional water is allocated. If water is allocated to the environment, drinking water supplies or recreation, positive economic benefits will evolve[13]. However, the potential does exist for slight negative impacts to occur due to impacts on flood mitigation and infrastructure. Despite this, it is estimated that positive benefits will outweigh negative impacts and therefore there will be a net economic gain for downstream water users in this catchment from the increased streamflow. The magnitude of this gain is considered to be significant.

4.4 CONCLUSIONS & DISCUSSION – UPPER NORTH EAST

Impacts on mean streamflow arising from the adopted logging scenario were similar across the three UNE catchments. That is, the sign of estimated impacts within each catchment were generally the same across representative cases. This allowed general conclusions to be drawn regrading the adopted logging scenario in each catchment.

For the three catchments examined in the UNE, the potential economic impacts estimated for downstream water users due to the adopted logging scenario are summarised in Table 4.V.

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[13] Assumes a benefit will accrue to the environment from additional water on the basis of the stressed river classifications in the *Stressed Rivers Assessment Report*.

Table 4.V: Potential Economic Impacts – Upper North East

Catchment	Potential Economic Impact			
	Agriculture ($'000)			Other
	Short Term	Medium Term	Long Term	
Eden Creek	$4 - $23	$7 - $44	-$2 – $67	Small Positive
Terania Creek	$3 - $20	$5 - $44	-$2 – $78	Small Positive
Upper Orara River	$8 - $55	$14 – $118	-$4 – $205	Positive

Therefore, a significant positive impact is estimated for the Upper Orara River catchment. For the other two catchments, a small positive economic benefit is estimated, although the magnitude of this impact is not deemed to be significant enough to drastically alter current water usage patterns and catchment profiles.

In general, other conclusions to be drawn from this analysis of UNE catchments include:

- the larger the positive impact on mean streamflow, the greater the net economic benefit to downstream water users;
- generally, (for the periods examined in the economic analysis), the longer the time period of analysis, the larger the increase in mean streamflow;
- the tree growth only component of the adopted logging scenario accounts for a larger proportion of the total impact observed under the adopted scenario than the logging only component;
- if the adopted logging scenario is applied to an old growth forest rather than a forest of current age, this produces significantly smaller impacts on mean streamflow, with negative impacts not uncommon in the long-term; and
- the implications for downstream water users of changes in the trends exhibited in the above analysis over the very long-term should be considered when analysing these economic results.

These conclusions are based on the estimated streamflow impacts given the output from the underlying hydrology study (SKM 1998) and the constraints of this study (data, time). More complete data sets (catchment-specific data) and sensitivity testing of key assumptions and outcomes would strengthen this analysis. Without such sensitivity testing it is difficult to make detailed comment on the distribution of estimated benefits and costs. Lack of sensitivity testing is therefore a limitation of this analysis, although one necessitated by time and information constraints.

The following section provides similar results for three catchments in the Lower North East (LNE) RFA region.

5. LOWER NORTH EAST

This section examines the economic impacts of the adopted logging scenario within each of the three catchments that are used as case studies in the LNE. The method of analysis of each catchment mirrors that approach adopted in the analysis of each of the three catchments in the UNE.

5.1 MANNING RIVER

5.1.1 Catchment Profile

The Manning River Catchment is part of the Manning River Basin situated on the mid-north coast of NSW. The major centre through which the Manning River flows is Taree. On the coastal fringe, dairying is the dominant landuse activity. Tourism is also a significant industry in this region. Further away from the coastal strip, both irrigated agriculture and tourism become less important.

5.1.2 Water Usage Profile

Estimates of water usage in the Manning River catchment are taken from DLWC (1998a). These estimates were based on measures taken at a gauge downstream from the gauges used in this study (Gauge 208004, and in addition, an allowance for Dingo Creek was used to estimate usage in the DLWC study). However, these estimates remain the most accurate and reliable estimates of water usage in this section of the Manning River catchment. Table 5.A lists the estimates of water usage both by agriculture and other industries in this catchment.

Table 5.A: Estimated Water Usage – Manning River

	Current Development – Estimated usages (ML)							
Industry	January	February	March	April	October	November	December	**Total[1]**
Irrigation	0	0	0	0	0	0	0	**0**
Other	1877.6	1627.3	1006.2	1006.2	1453.4	1118.0	1341.6	**9430**

Source: DLWC 1998a

[1] Hassall & Associates estimate. Estimates of total usage refer only to those months in which irrigation extractions take place.

It is clearly evident that there is no irrigated agriculture water usage within the Manning River catchment. Industrial and town usage is, however, quite significant. This unique water usage profile, (in comparison to the other catchments examined in this study), means that specific economic impacts related to sectors other than agriculture will arise.

5.1.3 Manning River Mean Annual Streamflow

Annual streamflow on the Manning River as measured at the forest gauge (208002) and the downstream gauge (208012) are listed in Table 5.B.

Table 5.B Mean Annual Streamflow – Manning River

Catchment Name	Gauging Station	Mean Annual Flow (ML)
Manning	208002 208012	39,000 110,000

Source: SKM 1998

5.1.4 Water Quality in Manning River

NSW Fisheries have identified the Manning River as having conservation value (DLWC 1998b). This assessment was made as part of the Stressed Rivers Assessment Process. This process also assigned environmental stress indicators to the Manning River catchment. These stress ratings are listed in Table 5.C.

Table 5.C: Environmental Stress Ratings – Manning River

Category	Stress Rating
Overall Stress Classification	Medium Environmental Stress[1]
Full Development Stress Classification	Medium Environmental Stress[2]
Hydrology Stress Rating	Low
Environmental Stress Rating	Medium

Source: DLWC 1998b

[1] assumes low extractions

[2] assumes high extractions

Assuming water quality will be most dependent upon the impact of sedimentation on mean streamflow, an examination of the impact that the adopted logging scenario has on sediment load is essential. The estimated range of sediment concentration in the Manning River catchment due to both a logging and a no logging scenario are presented in Table 5.D.

Table 5.D: Estimated Range of Sediment Concentration – Manning River

Catchment	Forest Gauge		Downstream Gauge	
	No Logging (mg/L)	Logging (mg/L)	No Logging (mg/L)	Logging (mg/L)
Manning	0.3 – 0.6	0.3 – 0.7	0.3 – 0.5	0.3 – 0.5

Source: SKM 1998

There is effectively no distinct variation in sediment load in the Manning River catchment between the logging and no logging scenario (recall that this is only in relation to sedimentation that is sourced from the forest. Sediment from agriculture and other industries is not included within this analysis). This is borne out both at the forest gauge and the downstream gauge. Furthermore, turbidity readings collected on the Manning River at Killawarra (further downstream from the downstream gauge), indicate a median rating of 1.6 NTU (SKM 1998). Given these two outcomes, it can be assumed that there is no significant impact on water quality due to the adopted logging scenario within this catchment.

5.1.5 Impacts of the Adopted Logging Scenario

The average annual impact of the adopted logging scenario on streamflow, as measured using the four representative cases and across timeframes at the forest gauge, are presented in Table 5.E.

Table 5.E: Average Annual Impact on Streamflow – Forest Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**-2.0%**	-3.3%	1.3%	0.6%
Medium Term (10 yrs)	**-3.6%**	-6.1%	2.5%	1.0%
Long Term (20 yrs)	**-5.6%**	-8.4%	2.8%	-0.3%

Unlike other catchments in the UNE and LNE, the adopted logging scenario will cause streamflow in the Manning River catchment to decline across timeframes. The implications of this decline in water availability will significantly impact upon downstream water users.

From Table 5.E, it is possible to conclude that:

- when the adopted logging scenario is applied to a forest of current age, mean streamflow will decline. The scale of this decline will increase as the timeframe is increased;
- however, the logging only component of the adopted logging scenario will cause an increase in mean streamflow. This suggests that taken in isolation, the logging activities will increase mean streamflow. It is the large negative impacts estimated under the tree growth only ("do nothing") component that offset these smaller positive impacts and cause a negative overall impact due to the adopted logging scenario; and
- if the adopted logging scenario was applied to an old growth forest, the logging only component would cause slight positive impacts in the short and medium-term, although in the long-term, a negative impact on mean streamflow is predicted. This indicates that in the very long-term, logging an old growth forest (in the manner of the adopted logging scenario) would result in a negative impact on mean streamflow.

The impacts of the adopted logging scenario on mean streamflow at the downstream gauge are listed in Table 5.F.

Table 5.F: Average Annual Impact on Streamflow – Downstream Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**-1.8%**	-3.0%	1.2%	0.6%
Medium Term (10 yrs)	**-3.2%**	-5.4%	2.2%	0.9%
Long Term (20 yrs)	**-5.0%**	-7.6%	2.5%	-0.3%

The impacts on mean streamflow at the downstream gauge mirror those trends exhibited at the forest gauge. Notably, as was the case at the forest gauge, this is the only catchment being examined as part of this study in which impacts on mean streamflow are predominantly negative.

5.1.6 Economic Impacts

Table 5.G outlines the indicative potential economic impacts estimated for the Manning River catchment. Whereas in the three UNE catchments the majority of impacts were of the same sign across all representative cases, impacts in the Manning River Catchment vary markedly across cases.

Given there are no abstractions of water for irrigated agriculture in the catchment, impacts on agriculture are assumed to be zero. Therefore, it is assumed that the impacts of changes in mean streamflow are absorbed by all other sectors. Given there are no impacts on agriculture, estimates were derived and are presented using a qualitative approach.

Table 5.G: Potential Economic Impacts – Manning River

Sector	**Potential Economic Impact**
Agriculture	Nil
Manufacturing	Negative
Infrastructure	Positive
Drinking Water Supplies	Negative
Flood Mitigation	Slight Positive
Recreation & Tourism Activities	Negative
Minimum Environmental Flows	Negative
Water Quality	Negative

From Table 5.G, if the adopted logging scenario is applied to a forest of current age, the potential economic impact on downstream water users is concluded to be significant and negative. This contrasts to the three UNE catchments, in which positive economic impacts were estimated to accrue to downstream water users.

If the adopted logging scenario was applied to an old growth forest, the economic impact is assumed to be slight and positive in the short and medium-term. The magnitude of this impact is not considered to be significant. However, in the long-term, a slight negative impact is estimated, though once again, this is not considered to be significant.

5.2 KARUAH RIVER

5.2.1 Catchment Profile

The Karuah River catchment includes the south-western portions of the Karuah River Basin. Irrigated agriculture abstractions in this catchment are dominated by dairying, with other licenses for horticulture also held. Industry abstractions in this catchment include sawmills and an engineering works in addition to the water supply for the township of Stroud. There are no tourist groups or facilities that abstract significant volumes of water in this catchment (Hassall & Associates 1996).

5.2.2 Water Usage Profile

A DLWC (1998a) estimate of the water usage profile in the Karuah River catchment is provided in Table 5.H. This data is indicative only, having been collected for the specific purpose of deriving hydrological indicators of rivers as part of the Stressed Rivers Program.

Table 5.H: Estimated Water Usage – Karuah River

	Current Development – Estimated usages (ML)							
Industry	January	February	March	April	October	November	December	**Total[1]**
Irrigation	144.23	108.2	60.1	48.1	168.3	204.3	156.2	**889**
Other	25.15	18.9	10.5	8.4	29.3	35.6	27.2	**155**

Source: DLWC 1998a

[1] Hassall & Associates estimate. Estimates of total usage refer only to those months in which irrigation extractions take place.

Industrial and town usage in the Karuah River catchment accounts for almost 15% of total water extractions in the months reported in Table 5.H. In comparison with the three catchments in the UNE, this proportion is notable. This suggests that other industries/activities in addition to agriculture will be important water users in the Karuah River catchment, contrary to UNE catchments in which the majority of water usage was accounted for by agriculture.

5.2.3 Karuah River Mean Annual Streamflow

Average annual streamflow in the Karuah River catchment is provided in Table 5.I. Estimates of mean annual flow are provided at both the forest gauge (209001) and the downstream gauge (209003).

Table 5.I Mean Annual Streamflow – Karuah River

Catchment Name	Gauging Station	Mean Annual Flow (ML)
Karuah River	209001 209003	145,000 237,000

Source: SKM 1998

5.2.4 Water Quality in Karuah River

The Karuah River catchment was identified as part of the *Stressed Rivers Assessment Report* by NPWS as having a high conservation value (DLWC 1998b). Stress ratings applied to the catchment within this report are presented in Table 5.J.

Table 5.J: Environmental Stress Ratings – Karuah River

Category	Stress Rating
Overall Stress Classification	Medium Environmental Stress[1]
Full Development Stress Classification	Medium Environmental Stress[2]
Hydrology Stress Rating	Medium
Environmental Stress Rating	Medium

Source: DLWC 1998b

[1] assumes low extractions

[2] assumes high extractions

Table 5.J shows that the overall environmental stress rating for the Karuah River catchment is medium. The impact of the adopted logging scenario on this existing environmental rating will be most easily measured by examining the impact of this scenario on sediment concentration. Table 5.K estimates the range of sediment concentration at both the forest gauge and downstream gauge under a logging and no logging scenario[14].

Table 5.K: Estimated Range of Sediment Concentration – Karuah River

Catchment	Forest Gauge		Downstream Gauge	
	No Logging (mg/L)	Logging (mg/L)	No Logging (mg/L)	Logging (mg/L)
Karuah River	0.3 – 0.6	0.4 – 0.9	0.2 – 0.4	0.3 – 0.5

Source: SKM 1998

Some variation in sediment concentration exists between the logging and no logging scenario, particularly at the forest gauge. This variation is less significant when

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[14] Recall that all concentrations in Table 5.K represent sediment load coming from the forest only, thereby ignoring sediment loads coming from agriculture and other industries within the catchment.

measured at the downstream gauge. Turbidity data collected by the DWLC on the Karuah River at Booral shows a median reading of 4.4 NTU. This level is safely within guidelines for drinking water.

Although logging scenarios in the Karuah River catchment may cause a slight decline in overall water quality, the quality of water, when measured in terms of acceptable standards for drinking water, is assumed not to be affected by logging activities.

5.2.5 Impacts of the Adopted Logging Scenario

The average annual impact of the adopted logging scenario on mean streamflow in the Karuah River catchment across the four representative cases (as measured at the forest gauge) are presented in Table 5.L.

Table 5.L: Average Annual Impact on Streamflow – Forest Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**0.7%**	-0.7%	1.5%	0.7%
Medium Term (10 yrs)	**1.8%**	-1.0%	2.9%	1.1%
Long Term (20 yrs)	**2.8%**	-0.4%	3.2%	0.3%

The impact on mean streamflow shows considerable variation across the representative cases. The trends exhibited across the representative cases differ from the trends noted in the UNE catchments and also differ from the trends exhibited in the Manning River catchment. Most notably in the Karuah River catchment, under the tree growth only component of the adopted logging scenario, estimated impacts on mean streamflow are negative. This contributes to the relatively small positive impacts that are estimated under the adopted logging scenario when applied to a forest of current age.

Also of note, is the fact that under both the tree growth only component of the adopted scenario and when the adopted scenario is applied to an old growth forest, impacts on mean streamflow are at their extreme in the medium-term, before switching direction in the long-term.

Average annual impacts on mean streamflow as measured at the downstream gauge are provided in Table 5.M.

Table 5.M: Average Annual Impact on Streamflow – Downstream Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	0.4%	-0.4%	0.9%	0.4%
Medium Term (10 yrs)	1.1%	-0.6%	1.7%	0.7%
Long Term (20 yrs)	1.7%	-0.2%	2.0%	0.2%

Key conclusions to be drawn from Table 5.M include:

- the annual average impact on mean streamflow when the adopted logging scenario is applied to a forest of current age is slightly positive across all timeframes;
- unlike the UNE catchments, the tree growth only component of the adopted logging scenario will cause mean streamflow to decline;
- the largest positive impacts on streamflow are estimated under the logging only component of the adopted logging scenario when it is applied to a forest of current age. The magnitude of these positive estimates, is however, small. Furthermore, the negative impacts under the tree growth component of the adopted logging scenario will partially offset these positive impacts; and
- when the adopted logging scenario is applied to an old growth forest, smaller positive impacts on mean streamflow are estimated. In the long-run, the magnitude of the positive impact on mean streamflow will begin to decline, most probably becoming negative in the very long-term.

Despite the variation in impacts on mean streamflow across the four representative cases and across different timeframes, all estimated impacts are of a small magnitude. When the adopted logging scenario is applied to either a forest of current age or an old growth forest, positive impacts are estimated over all timeframes. This infers that the potential economic impact of the adopted logging scenario on downstream water users will be slight and positive, and most probably, insignificant.

5.2.6 Potential Economic Impacts

Potential economic impacts incurred by downstream water users in the Karuah River catchment under the adopted logging scenario will not be significant. For those representative cases that estimate a positive impact on mean streamflow, the scale of this positive impact will be insufficient to generate economic impacts of a significant magnitude.

Estimates of potential economic impacts on downstream water users are provided in Table 5.N. Quantitative agricultural estimates are reported as they were in UNE catchments.

Table 5.N: Potential Economic Impacts – Karuah River

	Sector	Potential Economic Impact
EITHER	Agriculture	$15,000 - $32,000 (ST) $25,000 - $63,000 (MT) $7,000 - $70,000 (LT)
OR[2]	Manufacturing	Small Positive
	Infrastructure	Nil
	Drinking Water Supplies	Small Positive
	Flood Mitigation	Not Significant
	Recreation & Tourism Activities	Small Positive
	Minimum Environmental Flows	Small Positive
	Water Quality	Small Negative/Insignificant

1. ST = Short Term (5 yrs), MT = Medium Term (10 yrs), LT = Long Term (20 yrs). All estimates are average annual impacts.
2. Impacts on other industries/activities (excluding agriculture) may be mutually exclusive. Potential economic impacts should therefore not be summed.

Therefore, a small positive impact is estimated to accrue to downstream water users in the Karuah River catchment when the adopted logging scenario is modelled. Potential economic benefits derived under this scenario are assumed to be insignificant when placed in the context of aggregate agricultural economic activity on the North Coast. Indeed, if additional streamflow is diverted to agriculture, the maximum potential gain in the long-term is approximately $70,000 per annum[15].

5.3 JILLIBY JILLIBY CREEK

5.3.1 Catchment Profile

Jilliby Jilliby Creek lies within the Macquarie-Tuggerah Lakes Basin. Major centres within this river basin include The Entrance, Wyong, Morisset and Swansea. The basin is predominantly coastal and is dominated by a chain of coastal lakes. Within the inland part of the basin, which includes Jilliby Jilliby Creek catchment, there is limited irrigated agriculture. There are no significant towns or industries within the catchment.

5.3.2 Water Usage Profile

The water usage profile in the Jilliby Jilliby Creek catchment, as estimated by DLWC (1998a), is provided in Table 5.O. This data is intended only as an indicative estimate of water usage patterns amongst agriculture and other (towns and industry) water users in this catchment.

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[15] This compares to a gross value of agricultural production on the North Coast of $511 million (1991/92 dollars) (DWR 1994).

Table 5.O: Estimated Water Usage – Jilliby Jilliby Creek

	Current Development – Estimated usages (ML)							
Industry	January	February	March	April	October	November	December	**Total[1]**
Irrigation	41.03	28.4	18.9	9.5	41.0	56.8	44.2	**240**
Other	0	0	0	0	0	0	0	**0**

Source: DLWC 1998a

[1] Hassall & Associates estimate. Estimates of total usage refer only to those months in which irrigation extractions take place.

Table 5.O shows that irrigated agriculture is the only water user in this catchment. Monthly water usage varies throughout the year, however, this is reflective of normal irrigated agriculture water demand patterns.

5.3.3 Jilliby Jilliby Creek Mean Annual Streamflow

Average annual streamflow in the Jilliby Jilliby Creek catchment as measured at both the forest gauge (211004) and the downstream gauge (211010) is provided in Table 5.P.

Table 5.P Mean Annual Streamflow – Jilliby Jilliby Creek

Catchment Name	Gauging Station	Mean Annual Flow (ML)
Jilliby Jilliby Creek	211004 211010	1,300 24,000

Source: SKM 1998

Of note in Table 5.P, is the large increase in streamflow between the forest gauge and the downstream gauge. This reflects the fact that there are many tributaries that enter into Jilliby Jilliby Creek between these two gauge locations.

5.3.4 Water Quality in Jilliby Jilliby Creek

The NPWS has identified Jilliby Jilliby Creek as having conservation value. This was determined during the compilation of the *Stressed Rivers Assessment Report* (DWLC 1998b). This report identified high stress ratings for Jilliby Jilliby Creek. These stress ratings are listed in Table 5.Q.

Table 5.Q: Environmental Stress Ratings – Jilliby Jilliby Creek

Category	Stress Rating
Overall Stress Classification	High Environmental Stress[1]
Full Development Stress Classification	High Environmental Stress[2]
Hydrology Stress Rating	High
Environmental Stress Rating	High

Source: DLWC 1998b

[1] assumes low extractions

[2] assumes high extractions

Obviously, Jilliby Jilliby Creek is identified as suffering from high hydrology and environmental stress. Therefore, the impact of the adopted logging scenario on mean streamflow in this catchment will be very important.

One measure of identifying the impact of the adopted logging scenario on water quality within the stream is to examine the estimated sediment load in the creek under both a logging and a no logging scenario. Table 5.R reproduces results as reported in SKM (1998) with respect to sediment load estimates in Jilliby Jilliby Creek catchment[16].

Table 5.R: Estimated Range of Sediment Concentration – Jilliby Jilliby Creek

Catchment	Forest Gauge		Downstream Gauge	
	No Logging (mg/L)	Logging (mg/L)	No Logging (mg/L)	Logging (mg/L)
Jilliby Jilliby Creek	3.1 – 6.3	3.5 – 7.0	1.1 – 2.3	1.3 – 2.5

Source: SKM 1998

As measured at the downstream gauge, there is some variation in sediment load between the logging and no logging scenario. This indicates that the adopted logging scenario will increase sediment load within catchment waterways, however the magnitude of this increase will not be significant. There is slightly greater variation in sediment load (as well as greater actual load volumes) when measured at the forest gauge. Lower estimates of sediment load at the downstream gauge reflect the diluting effect caused by increased streamflow within the creek downstream of the forest gauge.

5.3.5 Impacts of SKM Logging Scenarios

Estimates of the impact of the adopted logging scenario on annual average streamflow, as measured at the forest gauge, are provided in Table 5.S. Estimates are reported using the four representative cases to broaden the understanding of particular impacts caused by the adopted scenario.

Table 5.S: Average Annual Impact on Streamflow – Forest Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**7.5%**	-1.1%	8.6%	4.8%
Medium Term (10 yrs)	**14.2%**	2.0%	12.2%	5.6%
Long Term (20 yrs)	**22.8%**	13.8%	9.0%	-3.0%

The adopted logging scenario in the Jilliby Jilliby Creek catchment has significant influence on mean streamflow at the forest gauge. Certainly, there is much greater

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[16] Recall that all concentrations in Table 5.R represent sediment load coming from the forest only, thereby ignoring sediment loads coming from agriculture and other industries within the catchment.

variation in estimated impacts on mean streamflow in the Jilliby Jilliby Creek catchment then is estimated for any other catchment in either the UNE or LNE.

Impacts of logging scenarios as measured at the downstream gauge are presented in Table 5.T.

Table 5.T: Average Annual Impact on Streamflow – Downstream Gauge

	Representative Case			
	Current Conditions			Old Growth
	Logging plus tree growth scenario	Tree growth only component	Logging only component	Logging Scenario
Short Term (5 yrs)	**2.7%**	-0.4%	3.1%	1.7%
Medium Term (10 yrs)	**5.1%**	0.7%	4.4%	2.0%
Long Term (20 yrs)	**8.2%**	4.9%	3.2%	-1.1%

Estimated impacts on mean streamflow are considerably smaller when measured at the downstream gauge in comparison to estimates measured at the forest gauge. Once again, the marked increase in streamflow between the forest gauge and the downstream gauge decreases the proportional impact that the adopted logging scenario exerts upon mean streamflow at this downstream gauge. Despite this, impacts on mean streamflow in the Jilliby Jilliby Creek catchment are greater than those estimated impacts in other catchments in this study.

From Table 5.T it is possible to conclude that:

- the largest impacts on streamflow are estimated to occur when the adopted logging scenario is applied to a forest of current age. Positive impacts of over 8% in the long-term represent significant effects upon mean streamflow;
- the tree growth only component of the adopted logging scenario accounts for a significant proportion of the total positive impact in the long-term, despite accounting for a small proportion of the total positive impact in the short and medium-term. The influence of forest re-growth in the long-term is, therefore, quite significant;
- on the other hand, the logging only component of the adopted logging scenario maintains a relatively static positive impact on mean streamflow;
- if the adopted logging scenario is applied to an old growth forest, positive impacts on mean streamflow will peak in the medium-term, becoming negative in the long-term; and
- this suggests that very long-term impacts will continue to be negative. This has implications for downstream water users if the adopted logging scenario is applied to an old growth forest.

An examination of the potential economic impacts arising from the influence of the adopted logging scenario on downstream water users is provided in the following section.

5.3.6 Potential Economic Impacts

Table 5.U provides an indicative estimate of the potential economic impact of the adopted logging scenario on sectors that are dependent on water resources in the Jilliby Jilliby Creek catchment.

Table 5.U: Potential Economic Impacts – Jilliby Jilliby Creek

	Sector	Potential Economic Impact
EITHER	Agriculture	-$14,000 - $111,000 (ST) $25,000 - $183,000 (MT) $116,000 - $294,000 (LT)
OR[2]	Manufacturing	Nil
	Infrastructure	Slight Negative
	Drinking Water Supplies	Nil
	Flood Mitigation	Negative
	Recreation & Tourism Activities	Positive
	Minimum Environmental Flows	Positive
	Water Quality	Slight Negative

1. ST = Short Term (5 yrs), MT = Medium Term (10 yrs), LT = Long Term (20 yrs). All estimates are average annual impacts.
2. Impacts on other industries/activities (excluding agriculture) may be mutually exclusive. Potential economic impacts should therefore not be summed.

Despite agriculture being the only industry that uses water in the Jilliby Jilliby Creek catchment, the economic impacts derived under the adopted logging scenario are significant. If irrigated agriculture has access to additional streamflow, the long-term beneficial impact will range to as much as $294,000 per annum. If water is allocated to either the environment or recreation and tourism activities, positive impacts will occur. At the same time, negative impacts will accrue to infrastructure and flood mitigation. Given there are no extractions for industry or towns, it is assumed each of these industries will not be affected by changes to streamflow.

5.4 CONCLUSIONS & DISCUSSION – LOWER NORTH EAST

For the three catchments examined in the LNE, the economic impacts estimated for downstream water users are more variable than those impacts estimated within the UNE catchments. In the UNE, impacts tended to be similar across all four representative cases. However, in the LNE there was often a distinct variation in impacts across different cases.

Table 5.V summarises the potential economic impacts incurred given the implementation of the adopted logging scenario either within a forest of current age or an old growth forest.

Table 5.V: Potential Economic Impacts – Lower North East

Catchment	**Potential Economic Impact**			
	Agriculture ($'000)			**Other**
	Short Term	Medium Term	Long Term	
Manning River	Nil	Nil	Nil	Negative
Karuah River	-$16 - $32	-$23 - $63	-$8 - $70	Small Positive
Jilliby Jilliby Creek	-$14 - $111	$25 - $183	-$39 - $294	Positive

Therefore, the economic impacts expected to accrue to downstream water users under the adopted logging scenario are:

- a significant negative impact in the Manning River catchment;
- a small positive impact in the Karuah River catchment; and
- a significant positive impact in the Jilliby Jilliby Creek catchment.

In general, other conclusions to be drawn from this analysis of LNE catchments include:

- the greater variation of estimated impacts across the representative cases when compared to estimated outcomes in the three UNE catchments;
- the greater divergence from trends exhibited in the UNE across alternative cases and over alternative timeframes (ie whereas in the UNE impacts generally peaked in the long-term, in the LNE maximum (positive) and minimum (negative) impacts on mean streamflow occurred in both the medium-term and long-term;
- the distinct variation in estimated impacts on mean streamflow across catchments. For instance, in the UNE, positive economic impacts were estimated for all three catchments. In the LNE, on the other hand, a significant negative impact was estimated in the Manning River catchment, a slight positive impact was estimated in the Karuah River catchment and a significant positive impact was estimated for Jilliby Jilliby Creek catchment; and
- as in the UNE catchments, it is important to be aware of the very long-term impacts on mean streamflow and the variations that may arise in very long-term impacts when compared to estimated long-term impacts in this study. Recognising the associated implications of such changes for downstream water users is an important element of interpreting the results included within this economic analysis.

In summary, there was much greater divergence in estimated impacts in the LNE catchments than was exhibited in the relatively uniform estimated impacts in the UNE catchments. As for the UNE, time and information constraints precluded sensitivity testing of key assumptions and results in the LNE. Such testing would have strengthened the economic analysis.

6. EXTRAPOLATING REGIONAL IMPACTS

6.1 INTRODUCTION

In order to estimate the economic impact of logging scenarios at a regional level, it is necessary to extrapolate results based on the analysis conducted at the catchment level. Given the predominantly qualitative nature of the outputs generated at the catchment level, extrapolated estimates of regional impacts are indicative only. These estimates are used as much to indicate the sign of impacts (either positive or negative) as they are used to indicate order of magnitude.

6.1.1 Methodology

When seeking to extrapolate regional impacts from catchment estimates, there is a series of information that is required. For each region this includes the:

- impact that the adopted logging scenario has upon mean streamflow in each catchment;
- proportion of total river basin flow which each catchment stream accounts for;
- number of catchments within a river basin; and
- number of basins within a region.

Initially, this information allows us to derive the proportional impact that an adopted logging scenario will have (measured in terms of change in streamflow) at a river basin level. The impact each scenario has on catchment streamflow is scaled to a basin level by examining the proportion of streamflow that each catchment stream contributes to the major river within a basin.

Since we only examined three catchments as case studies within each region, the total number of catchments within each basin must be estimated. We assume that the impacts within each individual catchment that were not studied will be similar to those impacts that were estimated within the three case study catchments examined in each region. Taking account of the impacts that occur in non-modelled catchments provides us with basin level impacts. Finally, by examining the number of river basins within each region, the basin level impacts can be scaled to a regional level.

6.1.2 Upper North East

Extrapolation of regional economic impacts in the UNE is possible given the similar nature of the impacts within each of the catchment case studies. Across catchments there is a degree of consistency in the estimated economic impacts; namely, that a positive economic benefit will accrue to downstream water users under the adopted logging scenario. Obviously, the actual scenario that is adopted and the timeframe over which analysis occurs will influence the potential economic benefit that can be derived. However, in general, it can be estimated that at a regional level, adopted logging scenarios will have a slight and beneficial impact upon downstream water users.

6.1.3 Lower North East

Based on the results derived from the three catchment case studies in the LNE, it is not possible to adequately extrapolate regional impacts. Unlike the UNE, where impacts in each of the catchments were of the same sign, and were of similar magnitudes, in the LNE the wide divergence in estimated impacts between catchments rendered regional extrapolations ineffectual.

7. CONCLUSIONS

This study examined the economic impact of adopted logging scenarios on downstream water users over time. By examining the relationship between logging activities and streamflow, potential economic impacts on downstream water users arising from changes in mean streamflow were analysed, and where possible quantified. Attempts were made to extrapolate regional economic impacts based upon three catchment case studies in both the UNE and LNE RFA regions. Although the study provided a thorough overview of potential economic impacts that may occur over a reasonable economic analysis time period (20 years), attention was drawn to the potential for estimated impacts to differ over longer timeframes. Furthermore, time and data constraints limited the ability of the study results to be tested for precision and subsequent refinements to be made.

8. REFERENCES

Carlos C (1991) *What is Town Water Worth?*, Australian Journal of Soil and Water Conservation 4 (3): 32-36

Centre for International Economics (1997) *A Study to Assess Environmental Values Associated with Water Supply Options: Community Values Study Final Report*, ACTEW Corporation, Canberra

Department of Water Resources (1994) *Water Resources of the North Coast…doing more with water*, NSW Department of Water Resources

Department of Water Resources (1989) *New South Wales River Basin Maps*

Dwyer Leslie (1991) *Cost-Benefit Analysis of the Drinking Water Quality Program: A Contingent Valuation Approach*, Report prepared in conjunction with the Sydney Water Board

Hassall & Associates (1998a) *Economic and Financial Evaluations for the Blue Mountains Sewerage Program: Draft Report*, June 1998

Hassall & Associates (1998b) *Socio-Economic Aspects of Water Reforms, Draft Report*, February 1998

Hassall & Associates (1996) *Economic Impacts of River Flow Objectives*, a report prepared for New South Wales Environmental Protection Agency, May 1996.

Hill C.M. (1994) *Water Quality Improvements in the Darling River: A Contingent Valuation Study*, WPD Occasional Paper Series 94.1, Department of Water Resources

Morrison M.D., Bennett J.W. & Blamey R.K. (1998) *Valuing Improved Wetland Quality Using Choice Modelling*, Choice Modelling Research Report No. 6, University College, University of NSW

NSW DLWC (1998a) *Catchment Water Usage Data*, provided by Justine Harris, Water Analysis & Audit Officer, DLWC, Parramatta, October 1998

NSW DLWC (1998b) *Stressed Rivers Assessment Report: NSW State Summary*, NSW DLWC, Sydney

NSW DLWC (1997) *A Stressed Rivers Approach to the Management of Water Use in Unregulated Streams*, NSW DLWC, Sydney

NSW EPA (1997) *New South Wales: State of the Environment 1997*, NSW Environmental Protection Agency, Chatswood

NSW EPA (1995) *NSW EPA Environmental Valuation Database*, NSW Environmental Protection Agency, Chatswood

NSW Treasury (1997) *NSW Government Guidelines for Economic Appraisal*, Office of Financial Management, Policy & Guidelines Paper, June 1997

Sinclair Knight Merz (1998) *ESFM Project: Water Quality and Quantity for the Upper and Lower North East, Southern RFA Regions*, A project undertaken as part of the NSW Comprehensive Regional Assessments, Project Number NA 61/ESFM, Draft A, September 1998