INTEGRATED FRESHWATER SOLUTIONS

COST BENEFIT ANALYSIS OF SELECTED OPTIONS TO IMPROVE WATER QUALITY IN THE MANAWATŪ RIVER CATCHMENT

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Published by Ecological Economics Research New Zealand

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EXECUTIVE SUMMARY

This report is material prepared for the Cost Benefit Analysis (CBA) section of the 2 November, 2011 Integrated Freshwater Solutions (IFS) Economics of the Manawatū River Catchment (MRC) "Whose Bang for Whose Buck?" workshop. The report starts with an overview of the MRC economy. It then provides a CBA for five alternative actions based on the Manawatū River Leaders Accord Action Plan. These are:

- Dairy: Actions A, B and C cover different combinations of mitigation measures for dairying
- Sheep and Beef: Actions A, B and C cover different combinations of mitigation measures for sheep and beef farming
- Sustainable Land Use Initiative: Action D covers taking steep hill country out of pastoral production and planting exotic forest
- Wastewater Treatment Plant: Action E looks at the options for upgrading wastewater treatment to improve point source discharge quality

Some actions are interdependent, for example, reducing sediment run-off reduces phosphorous loading. Therefore, undertaking some actions will provide multiple benefits. The cost and benefit calculations have drawn on data used in the 2010 Waikato River Scoping Study. For the CBA not all costs and benefits can be quantified due to lack of data. This material should, therefore, be seen as an indication of possible outcomes, rather than a final calculation for the MRC.

As was found with the Waikato River Independent Scoping Study (NIWA, 2010) the cost for remedial actions to reduce pollution to waterways is significant. This is a barrier to any of the proposed actions being implemented. For the MRC if costs and improvements to water quality are considered to be of equal importance then SLUI, Action D can achieve the best overall outcome. SLUI is also the best option when sediment and phosphorous removal are considered to be twice as important as nitrogen. Action B Dairy is a good alternative if N removal is considered twice as important as sediment removal.

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1. MANAWATŪ CATCHMENT INTEGRATED FRESHWATER SOLUTIONS ECONOMIC ANALYSIS

1.1 Introduction

The Manawatū River Leaders Accord (Horizons Regional Council, 2011) set out four goals for a desirable state of the river. These are: The Manawatū River becomes a source of regional pride and mana (2) Waterways in the Manawatū Catchment are safe, accessible, swimmable, and provide good recreation and food resources (3) The Manawatū Catchment and waterways are returned to a healthy condition, and (4) Sustainable use of the land and water resources of the Manawatū Catchment continues to underpin the economic prosperity of the Region. This report is providing information relevant to goal 4.

Both in the workshops and in the survey feedback the view was often expressed that solutions could not be decided on without at least ball-park cost indications. Prioritising solutions in the Action Plan was not considered possible without economic information. This Cost Benefit Analysis (CBA) is an attempt to move in this direction by providing some information on costs and potential outcomes from actions. While it was accepted that there were too many unknowns to put timeframes in place for setting a date for when the river is clean, it was generally agreed, that individual actions could have target times set against them and cost estimates.

The tension between the desire for economic gain and prevention of environmental degradation was recognized in the workshops. While the benefits of the current pastoral activity to the region were acknowledged there was a desire to explore whether investing in options that enhance the river could provide better long term economic outcomes.

Both the science used to determine preferred options and the costs applied to rank options can be disputed. This study draws on both the science and cost estimates provided by the Waikato River Independent Scoping Study (NIWA, 2010), and can therefore, only provide an indication of possible cost/benefits, rather than an accurate calculation for the MRC.

The 'Whose Bang for Whose Buck' workshop held on November 2, 2011 had the intended purpose of: (1) educating stakeholders on the methodologies and limitations of various economic approaches (2) demystifying the tools, and (3) providing an insight into the cost/effort involved in deploying economic tools.

1.1.1 Land use Activity in the MRC

The main land use activity in the MRC is farming. Percentages and estimates for land use change between 1990 and 2010 are given in Table 1. The methodology to estimate hectares in each land use category is provided in Appendix B.

Table 1: MRC land use types and estimated change between 1990 and 2010 (Hectares)

Land Use (ha)	**1990**	**2010**	**2010 % total ha**	**% change 1990-2010**
Cropland	6241	6299	1.1	0.83%
Grassland minus dairy	404978	365747	62.2	-8.68%
Dairy	45000	77022	13.1	63.73%
Other	7284	7217	1.2	-0.83%
Water	2338	2338	0.4	0.00%
Wetland	241	229	0.0	-4.45%
Woody Grassland	31975	31284	5.3	-1.94%
Natural Forest	81997	81338	13.8	-0.72%
Planted Forest	8393	16973	2.9	92.01%
Total	588447	588447	100.0	

See Appendix B for calculation methodology

As can be seen from Table 1 grassland used mainly for sheep and beef farming (but also deer farming and other small scale activities) is declining and dairying and planted forest is increasing. In 2007 approximately 10.5% of Full Time Equivalent Employment and 8.6% of Gross Domestic Product (GDP) were generated by the primary sector activities in MRC. Data for calculating employment in the primary sector and GDP was obtained from the "Wider Manawatu Region: Profile and Projections: TLA Analysis" (BERL Economics 2009). This BERL Economics report provided data for the four Territorial Local Authorities (TLAs) in the MRC for 1997, 2005, 2006, and 2007. The percentage of population in the MRC as a percentage of the total TLA populations was used to estimate employment (Figure 1) and GRP (Figure 2) in the MRC by TLA for the years 1997, 2005, 2006, and 2007. These figures were summed to get the total for the MRC.

The BERL Economics report (2009) provided projections for employment and GDP in 2016 and 2026 for each TLA. Two different scenarios were used. "The first is a neutral scenario, where industries in the region grow at the same rate as nationally. The second is a historical scenario, where industries in the region grow relative to how they have grown over the last 10 years. The neutral scenario provides a more positive projection of employment and GDP growth for the region as it is based on absolute national industry projections. However, we would suggest that the historical projection is the more likely outcome as it reflects the relative performance of the Wider Manawatu Region over the last 10 years." (BERL Economics, 2009, p.3). The downscaled data for the MRC and historical projection out to 2016 and 2026 for employment and GDP are shown in Figures 1 and 2. The BERL projections based on 2007 data do not anticipate a significant increase in employment or contribution to GDP from the primary sector.

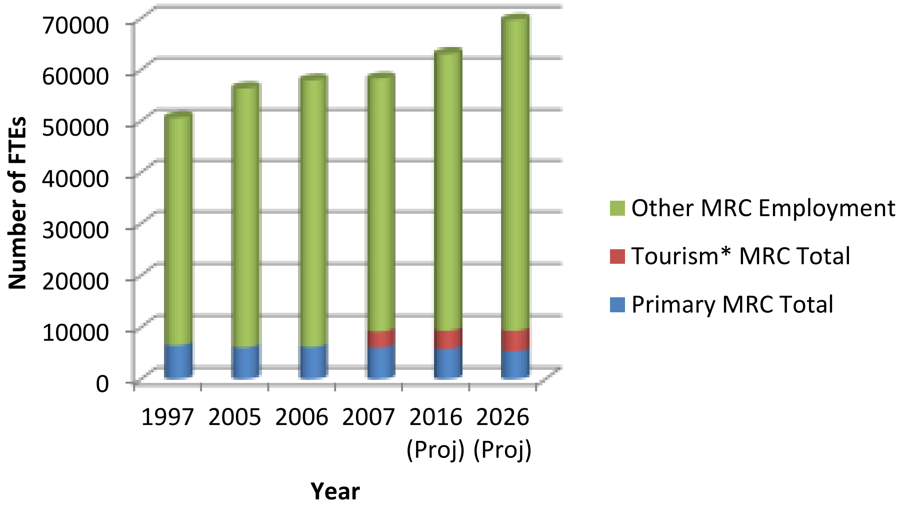


Figure 1: Total Full Time Equivalent Employment FTE) in MRC and Primary Sector 1997-2007 *[1]

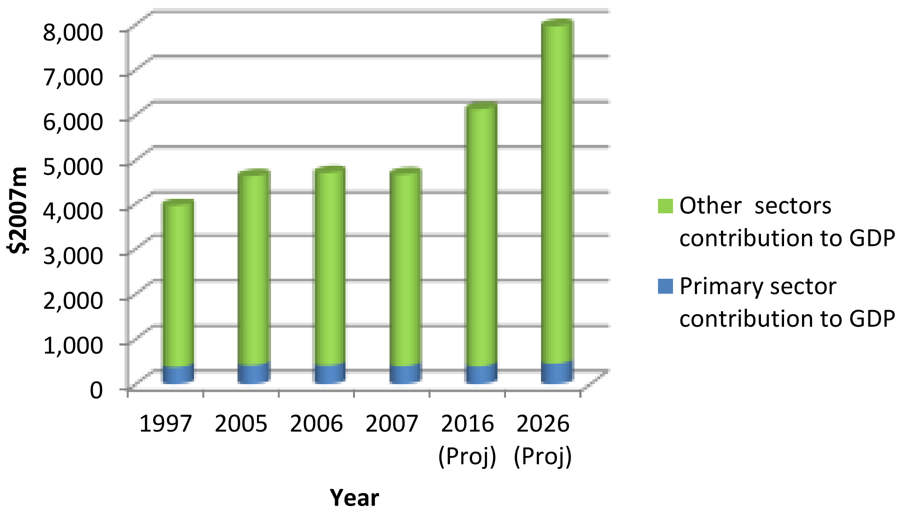


Figure 2: Total MRC GDP and contribution from the primary sector 1997-2007

The agricultural sector purchases goods and services from a number of industries in the region. Table 2 gives the top 8 industries (BERL Economics, 2008) that provide inputs to the agricultural sector in the Wider Manawatū Region. [2]

[1] Tourism data only available for 2007

[2] The Wider Manawatū Region cover Palmerston North City and the districts of Manawatū, Horowhenua and Tararua. This region is greater than the MRC but economic effects are distributed over a larger area.

Table 2: Wider Manawatū Region Agriculture input industries

Wider Manawatū Region Agriculture	% of intermediate inputs
Livestock and cropping farming	24.01
Wholesale and retail trade	16.68
Services to agriculture, hunting and trapping	12.30
Other business services	5.20
Finance and insurance	4.56
Other farming	3.69
Road freight transport	3.00
Fertiliser and other industrial chemical manu.	2.24
Communication services	2.24

Source: BERL Economics (2008)

The MRC primary sector provides the raw materials for the manufacturing sector. Over 65% of agricultural output is processed by other industries in the Wider Manawatū Region (BERL, 2008). Meat processing works (Manawatū Beef Packers, Country Meats, Ovation NZ Ltd) are located in the catchment. Milk processing takes place at Longburn and Mangatainoka Fonterra plants. Milk is also sent by rail to Taranaki which is outside the region. This creates employment opportunities and the associated multiplier effects in the local economy. Table 3 gives the percent of intermediate inputs going to the manufacturing and processing industries in the Wider Manawatū Region. Farming is by far the greatest.

Table 3: Wider Manawatū Region Manufacturing and Processing input industries

Wider Manawatū Region Manufacturing/Processing	% of intermediate inputs
Dairy and Cattle farming	23.26
Livestock and cropping farming	16.84
Wholesale and retail trade	8.59
Structural, sheet and fabricated metal product manu	5.2
Road freight transport	4.82
Other business services	3.69
Dairy manufacturing	3.38
Meat manufacturing	2.82
Other food manufacturing	2.59

Source: BERL Economics (2008)

1.1.2 Population Change in the MRC

The economy of the MRC is also influenced by the population that live and work there. As can be seen from Table 4 population of the MRC has increased between 1996 and 2010 though not by much (4% over 14 years). The percentages indicate how much of the total population for each Territorial Authority is estimated to be in the MRC.

Table 4: Population Estimates for the MRC

Year	Manawatū District (86%)	Palmerston North City 100%	Tararua District (92%)	Horowhenua District (32%)	Total MRC population
1996	24,667	75,200	18,003	9,849	127,718
2001	24,277	75,200	16,862	9,683	126,022
2006	25,124	78,500	16,706	9,542	129,872
2010	25,730	81,300	16,429	9,542	133,001

Source: Statistics NZ

1.2 Cost Benefit Analysis

Cost–benefit analysis (CBA)[3] is the most common method used for calculating and comparing the benefits and costs of a project to decide whether the investment is worthwhile (there is a return on investment) and how the proposed investment compares with alternative projects. The total expected costs overtime of a project are compared against the total expected benefits overtime. Adjustment is made for the opportunity cost of money so that the flows of benefits and costs which typically occur over different time periods are expressed in current day monetary amounts to allow comparisons to be made. As a result CBA is a single criteria approach which uses net present value (NPV) as the criterion. The discount rate of 8%, the current Treasury rate for public investment, was used in this analysis.

1.2.1 Cost Benefit Analysis of Options for the Manawatū River Clean-Up

The costs and benefits of the different options for cleaning up the Manawatū River have been based on costs and benefits used in the Waikato River Independent Scoping Study (WRISS). Comprehensive cost and benefit analysis were undertaken for the multitude of activities needed to restore water quality to the Waikato River as part of the WRISS which was released in December 2010. For the Manawatū River catchment (MRC) it has been assumed cost and benefits related to farming changes will be similar to those for the Waikato catchment. While it would be ideal to have costing data specific to the Manawatū this was not possible due to time and resource limits. The Waikato study involved between 20-30 scientists and had a budget in excess of $500,000. Consequently this section of the report should be regarded as a discussion starter rather than a fully-fledged CBA based on Manawatū data.

1.2.2 The Manawatū River Catchment CBA Approach

Two different land-use categories (Dairy farming and Sheep and Beef farming) were used for the Manawatū river catchment (MRC) farming option analysis. Farm profit data has been extracted from MAF’s 2011 Farm Monitoring Programme. For dairy farming the profit is $1,592 per ha as per the Lower North Island Dairy Model Budget (MAF, 2011a). The estimated land area for dairying in the MRC is 77,022 ha. For Sheep and Beef farming the profit is $180 per ha as per the North Island Hill Country Sheep and Beef Model Budget (MAF, 2011b). The estimated land area for sheep and beef farming in the MRC is 365,747 ha.

[3] Also referred to as benefit–cost analysis (BCA)

The capital costs and annualised operating costs are as used in the WRISS where possible (NIWA, 2010, Appendix 10, Table 4) included in Appendix A of this report. The increase in profit per ha from the different Actions undertaken are as per the WRISS study. There are a number of models that can be used for farm profitability analysis and each provides different dollar amounts depending on the farm scenario applied. According to the WRISS study (NIWA,2010; Appendix 9, p.1) "… scientific understanding has been encapsulated into various computer models that allow predictions to be made of the water-quality benefits and costs (including any effects on farm profitability) of implementing different sets of restoration actions". Because the values used in the WRISS study were widely debated before acceptance they have been taken as the best available to use. Workshop participants were comfortable with transferring the numbers from the WRISS study for use in the MRC CBA study.

The following key indicators have been used in the CBA as per the WRISS study (NIWA, 2010, Appendix 9: Farms)

1. Farm profitability, dollars per hectare per year ($/ha/year)
2. Nitrogen leaching losses to water, kilograms of nitrogen per hectare per year (Kg/N ha/year)
3. Phosphorus loss to water, kilograms per hectare per year (kg/P ha/year)
4. Sediment loss to water, kilograms per hectare per year (kg/S ha/year)
5. Losses of the faecal bacteria Escherichia coli (Ecoli) to water, most probable number (MPN) multiplied by 10^9 per hectare per year.

Farm profitability comes from modelled data. It is for typical farms (1) dairy farm on free draining (2) Sheep and Beef farm on Class 3 land.

Fencing and riparian planting requirements are dependent on stream density and the extent of existing work undertaken. For stock exclusion in the MRC calculations it has been assumed these are as per the Waikato region set out in Table 5. For dairy it is taken that 44% of stream length has been fenced. For Sheep and Beef farms 39% of the length is assumed fenced.

Table 5: Fencing Density Required

Waikato	Percentage of ha requiring fencing	Total Stream density m/ha	Stream density m/ha requiring fencing
Fencing Dairy	56%	35	19.6 m/ha
Fencing Sheep and Beef	61%	50	30.5 m/ha

For the CBA the base case against which farm costs are measured is the status quo for the next 20 years (from 2011 to 2031). No allowance was made for greater intensification or change in the dairy/sheep and beef farming split when projecting the costs over time. Therefore, the hectares for each year in sheep and beef and dairy remain the same as present for next 20 years. This approach was also used for the WRISS study.

The five different actions evaluated are set out in Table 6. For actions (A-D), the proposed mitigations, the base loading/ha/yr and the assumed reductions/ha/yr are as in the WRISS study. Expected sediment reductions for the MRC (in red) are as estimated by John Dymond (pers. comm. 17 November, 2011).

Table 6: Actions and Costs Used for the Economic Analysis

Action	Actions Catchment Scale	Base loading/ha/yr	Assumed [4]reductions/ha/yr
A	Dairy 1. Full stock exclusion from streams using single-wire fencing. 2. Soil Olsen phosphorus levels reduced from 38 to 32 (economic optimum). 3. Effluent areas enlarged appropriate to effluent K (potassium) loading rates. 4. Additional one month's effluent pond storage; low application depth.	N leaching, 40 Kg P loss, 0.6 Kg Sediment 4000kg/ha/yr E.Coli 151 MPN/ha/yr (x10^15)	Nitrogen 16% Phosphorous 75% Sediment 2.5% E.Coli 79%
	Sheep and Beef 1. Exclusion of cattle from streams using single-wire electric fencing ($2/m) and provision of stock troughs and water supply ($2/m). Total cost = $6/m of stream to fence both sides.	N leaching, 15 Kg P loss, 0.75 Kg Sediment 9000kg/ha/yr E.Coli 1510 MPN/ha/yr (x10^15)	Nitrogen 4% Phosphorous 6% Sediment 2.5% E.Coli 24%
B	Dairy 1. Full stock exclusion from streams using single-wire fencing. 2. Soil Olsen phosphorus levels reduced from 38 to 32 (economic optimum). 3. Effluent areas enlarged appropriate to effluent K (potassium) loading rates. 4. Additional one month's effluent pond storage; low application depth. 5. Use of nitrification inhibitors (5% pasture production response assumed). 6. Wetlands installed on 1% of farm area (fencing out of seeps and bogs). 7. Five-metre buffers around all stream reaches, planted in natives. 8. Berms on sections of lanes to direct run-off away from streams. 9. No nitrogen fertiliser applied in winter months.	As Dairy above	Nitrogen 62% Phosphorous 89% Sediment 10% (5% for planting, 5% for wetland) E.Coli 93%
	Sheep and Beef 1. Exclusion of cattle from streams using single-wire electric fencing ($2/m) and provision of stock troughs and water supply ($2/m) and tree plantings (with sleeves) at 10 m spacings on each side of streams. Total cost = $8/m of stream to fence both sides.	As Sheep and Beef above	Nitrogen 6% Phosphorous 9% Sediment 5% E.Coli 24%

[4] This is for free draining dairy land

Action	**Actions Catchment Scale**	**Base loading/ha/yr**	**Assumed [4]reductions/ha/yr**
C	Dairy 1. Full stock exclusion from streams using single-wire fencing. 2. Soil Olsen phosphorus levels reduced from 38 to 32 (economic optimum). 3. Effluent areas enlarged appropriate to effluent potassium loading rates. 4. Additional one month's effluent pond storage; low application depth. 5. Use of nitrification inhibitors (five percent pasture production response assumed). 6. Wetlands installed on one percent of farm area (fencing out of seeps and bogs). 7. Five-metre buffers around all stream reaches, planted in natives. 8. Berms on sections of lanes to direct run-off away from streams. 9. No nitrogen fertiliser applied in winter months. 10. Winter grazing of paddocks for four hours only, then herds returned to a herd shelter	As dairy above	Nitrogen 66% Phosphorous 89% Sediment Sediment 10% (5% for planting, 5% forwetland) E.Coli 93%
	Sheep and Beef 1. Full stock exclusion from stream using an 8-wire post and batten fence, allowing a 15 m buffer planted with natives at 2,500 plants/ha (pb2). This larger buffer made the riparian area compliant for obtaining Kyoto compliant carbon credits. Total cost = $108/m of stream to fence both sides. These costings (excluding carbon credits) includes components for site preparation, weed control and monitoring of plant establishment and survival	As sheep and beef above	Nitrogen 24% Phosphorous 47% Sediment 5% E.Coli 45%
D SLUI	Sheep and Beef 1. Conversion of 39,000 ha of erosion prone S & B farms to forestry over a 10 year period at a rate of 3,900 ha/yr. The profit from S & B farming on this land has been assumed to be $180/ha/year.	As above assuming land in sheep and beef farming	Nitrogen 60%* Phosphorous 65% Full forestry 90% E.Coli 80%
E WWTP	1. Future WWTP upgrades that have been budgeted for by Territorial Authorities have been brought forward to 2011.	N leaching, ?? Kg/day P loss, ?? Kg/day Sediment - Nil E.Coli ???/day MPN/ha/yr (x10^15)	

Source: WRISS (NIWA, 2010, Appendix 9 Farms – Tables 4, 5 and 6 and– Appendix 10 Faecal Contamination Table 4 * Assumed to be as per Pine Afforestation Appendix 9, Table 3.

1.2.3 CBA Calculations

For each of the mitigation actions (A-E) capital and annualised operating costs were taken directly, where possible, from the WRISS study (NIWA, 2010; Appendix 10: Table 4). The costs used in the analysis for each Action are set out in Table 7.

Table 7: Actions and Costs Used for the Economic Analysis

		Capital Cost $/ha	Annualised Operating Cost $/ha/yr
Actions	**Dairy**		
1	Full stock exclusion from streams using single-wire fencing	47	5
2	Soil Olsen phosphorus levels reduced from 38 to 32 (economic optimum)	0	0
3	Effluent areas enlarged appropriate to effluent potassium loading rates	21	22
4	Additional one month's effluent pond storage; low application depth	83	7
	Total Actions 1-4	**151**	**34**
5	Use of nitrification inhibitors (five percent pasture production response assumed)		neutral
6	Wetlands installed on one percent of farm area (fencing out of seeps and bogs)	68	22
7	Five-metre buffers around all stream reaches, planted in natives	686	80
8	Berms on sections of lanes to direct run-off away from streams	10	2
9	No nitrogen fertiliser applied in winter months	0	34
	Total Actions 1-9	**915**	**172**
10	Winter grazing of paddocks for four hours only, then herds returned to a herd shelter	3400	136
	Total Actions 1-10	**4315**	**308**
Actions Sheep and Beef			
1	Exclusion of cattle from streams using single-wire electric fencing ($2/m) and provision of stock troughs and water supply ($2/m). Total cost = $6/m of stream to fence both sides.	220	7
2	Exclusion of cattle from streams using single-wire electric fencing ($2/m) and provision of stock troughs and water supply ($2/m) and tree plantings (with sleeves) at 10 m spacings on each side of streams. Total cost = $8/m of stream to fence both sides.	301	13
3	Full stock exclusion from stream using an 8-wire post and batten fence, allowing a 15 m buffer planted with natives at 2,500 plants/ha (pb2). This larger buffer made the riparian area compliant for obtaining Kyoto compliant carbon credits. Total cost = $108/m of stream to fence both sides. These costings (excluding carbon credits) includes components for site preparation, weed control and monitoring of plant establishment and survival.	4198	335

Notes for farming actions for Dairying:

1. Benefits from the Actions undertaken are included in the net increase in operating profit per hectare as modelled for the WRISS. These include (1) Reduced stock loss from fenced off waterways/swamp areas (2) Savings on fertiliser use (3) More intensive farming from herd homes. For Action A benefits are modelled at $23 per ha; Action B $199 per ha; Action C $408 per ha.
2. Costs are as per Appendix 10, Table 4 except for those detailed below. The costs for 'Dairy Free Drain' have been used.
3. For Action 3 'Effluent areas enlarged' capital costs are estimated at $50,000 for effluent spraying equipment spread over 10 years for a 230 ha farm (http://www.fonterra.com/wps/wcm/connect/fonterracom/fonterra.com/our+business/sustainability/clean+streams+in+action/bryan+roach+opunake). Annualised costs are assumed as $5/day for energy costs and 30 minutes per day labour at $25/hour for 300 days a year.
4. For Action 5 'Use of nitrification inhibitors' it was assumed costs and benefits would be neutral for dairy farms. This assumption was based on Carey et al, (2012, p.10) "Average increases of 14% DM in NI regions, even if biased to some degree by the Taranaki results, and the average 21% observed in SI regions would more than account for the costs of application if the increased pasture production is mostly converted into milk solids." The literature recognises that the cost effectiveness of nitrification inhibitors varies with soil type and climate.
5. For the CBA calculations the assumption is capital costs are implemented over a 10 year period.
6. Annual marginal operating costs are assumed to increase with the additional capital investment. No adjustment has been made for inflation.

Notes for the farming options for Sheep and Beef:

1. Base net operating profit per hectare remains the same at $180 for each option.
2. Costs are as per Appendix 10, Table 4. The costs for 'Sheep/Beef class 3 farm' have been applied.
3. Benefits from the Actions undertaken are accounted for as reductions in annualised operating costs. These have been estimated as (1) Reduced stock loss of .005 cattle/ha/yr calculated on 2 year steer value of $850 = $4.25. Assume same ($4.25/ha/yr) for stock health improvement from water supply (2) Reduced sheep loss .01 sheep/ha/yr calculated on a lamb/sheep value of $120 =$1.2. Assume same ($1.2/ha/yr) for stock health improvement from water supply.
4. For the CBA calculations the assumption is capital costs are implemented over a 10 year period.
5. Annual marginal operating costs are assumed to increase with the additional capital investment. No adjustment has been made for inflation.

Notes for Action D – SLUI:

In the Manawatū Catchment there are approximately 39,000 ha of land classed as highly erodible. This is land with the potential for severe erosion if it does not have protective woody vegetation (Dymond and Shepherd, 2006). Long term it is the big events like the February 2004 flood that need to be managed to reduce the impact on the river. The best way to do this is by providing vegetation cover on steep slopes. The river substrate has been dominated by the February 2004 flood for the last 7 years and sediment is only now starting to clear (J. Dymond, pers. comm. 17 November, 2011).

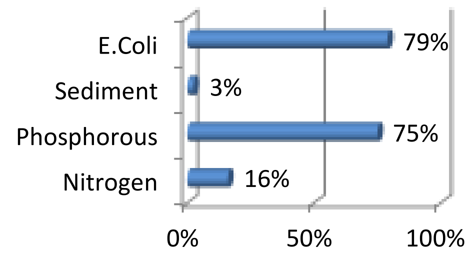
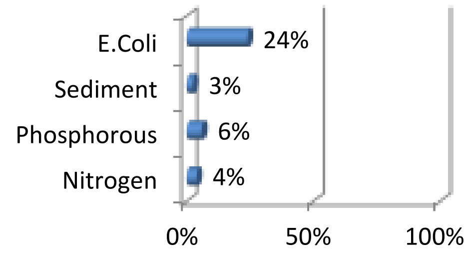
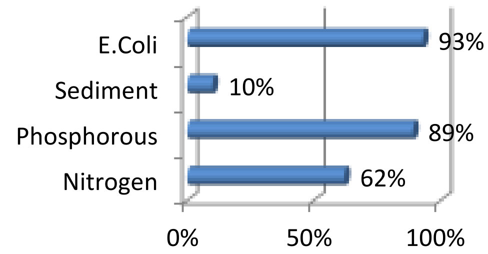
1. Expected outcomes from afforestation (rates from J. Dymond, pers. comm. 17 November, 2011).
   a. Hill country Sheep and Beef farm erosion rate is approximately 9000/kg/ha/yr. If this was converted to forestry it would reduce by 90% to 900 kg/ha/yr.
   b. Riparian planting on dairying and flat/rolling sheep and beef pastoral land will reduce sediment yield by 5%. This will be the same whether it is a narrow strip or up to 15 metres in width.
   c. A fenced strip without riparian planting will reduce erosion by half that amount (about 2.5%)
   d. Erosion on dairy land is approximately 4000/kg/ha/yr. Sheep and Beef farm converted to dairying would have the same rate as only land that is flat/rolling would be suited to conversion.
2. Capital costs are from WRISS (NIWA, 2010; Appendix 9: Farms (Appendix A) as for pruned trees. It is assumed that 3,900 ha (10%) of land severely eroding is planted each year for 10 years.
3. Operating costs are calculated for a 20 year period. Operating costs reflect the different stage each 3,900 ha block is at each year so costs vary per year depending on the point in the growing cycle.
4. Benefits from harvesting are not included as the CBA time period is 20 years and minimum mature tree growth time is 26-30 years. Profits/returns come in year 26 or later.
5. Benefits from carbon credits are not included though this would be possible. For the WRISS study, areas compliant for obtaining a carbon credit were assumed to accumulate carbon at a rate of 5 tonnes per hectare per year (NIWA, 2010; Appendix 10, p.4). For a radiata pine forest harvested after 30 years there is a 220 tonne per ha retention of carbon on site which is a one-off (MAF, 2010a, p. 7). At a $25 per NZU price this is $5500/ha or $183/ha/yr over a 30 year period.
6. The full SLUI environmental benefits are likely to come into play 8 years after tree planting. The main benefits are soil retention, reduced water treatment costs, reduced damage to infrastructure from slips, better aquatic habitat and improved visual amenity (Krausse, Eastwood et al. 2001). Soil retention benefits have been estimated based on preventing loss from Sheep and Beef farms of 9000 kgs/ha/yr. Assuming 25% is topsoil with a value of $30 per tonne this gives $67.50 per ha (Dymond, nd). There will also be potential savings from reduced flood protection costs though these are not expected to be large. Flood reduction costs are estimated at $2/ha/yr based on an approximate value of $0.9 m per year for the MRC (Dymond, nd).

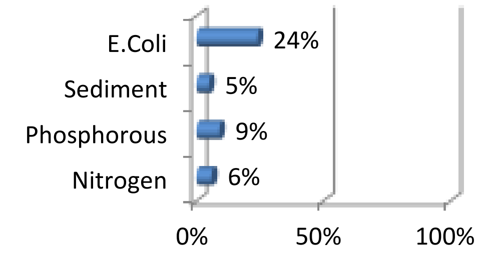
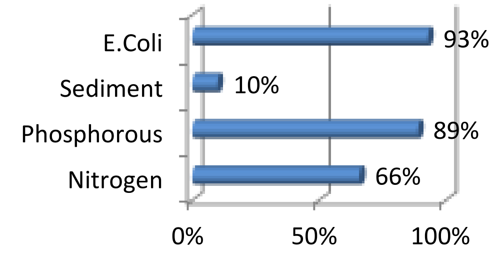
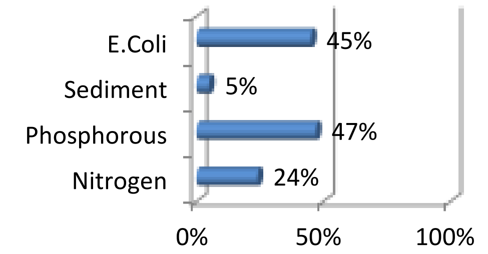
Notes for Action E – WWTP:

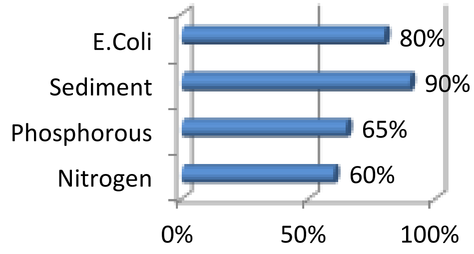
1. It has not been possible to source the actual costs and expected direct improvements in water quality from investments in Waste Water Treatment Plant (WWTP) upgrades. Some of the expenditure listed below, for example, the $20m for PNCC can be considered asset renewal rather than improvements.
2. It has also not been possible to directly link investment to improvements in water quality because what will be achieved in terms of water quality from the investment is unclear.
3. The capacity of the river to assimilate point discharges into the waterway is also unclear. PNCC is currently monitoring their discharge into the Manawatū River to see what the impact of the discharge is.
4. The capital plant upgrade costs used for this very preliminary estimate of potential WWTP investments are: Feilding ($7.8m), Dannevirke ($1.047m), Pahiatua ($1.7m), Kimbolton ($0.3m), Longburn ($0.3m), Eketahuna ($0.93m), Ashhurst ($2.1m) and PNCC ($20m). The PNCC $20m is the amount budgeted in 2027 to meet One Plan requirements brought forward. It was assumed all these upgrades took place in 2011. Total capital investment in year 1 was $34m. These figures are sourced from Council Long Term Plans (see Appendix A).
5. The WWTP investment is depreciated over 25 years. Interest cost is 8% per annum.
6. Operating and maintenance costs are based on 4% of the capital cost for Environmental Best Management Practice as per WRISS (NIWA, 2010: Appendix 14, p.22)
7. Benefits related to improving water quality from reduced nitrogen and phosphorous are not quantifiable.

Table 8 summarised the potential costs and benefits from Actions A-E. NPV sums are based on the costs and benefits over a 20 year period. Insufficient data for WWTP benefits means that this Action has not been further investigated.

Table 8: Summary of the Costs and Benefits for Actions A-E

Action	Capital Costs/ha	Annual Operating Cost/ha	Farm Benefits, NPV/ha	Other Community Benefits	Water quality benefits
A Dairy	Additional effluent storage $83/ha + Cow exclusion from streams (1 wire) $47/ha + Effluent areas enlarged $21	Effluent ponds $7/ha + Effluent spraying $22 + Single wire fence $5/ha	Reduced fertiliser Less stock loss Cash operating increase $23/ha NPV $/ha/yr $8	Reduced water treatment costs Flood protection savings Health cost savings Improved contact recreation Food gathering Improved ecosystem services	
A Sheep and Beef	Cattle exclusion from streams (1 wire) $200/ha	Cattle exclusion from streams $18/ha – (savings from reduced stock loss + improved health $11)	Easier farm management? Soil retention? NPV $/ha/yr $7	Reduced water treatment costs Flood protection savings Health cost savings Improved contact recreation Food gathering Improved ecosystem services	
B Dairy	Action A Costs + Wetland fencing $68 + Laneway berms $10 + 5m buffer planting $686	Action A Costs + Wetland $22/ha + Berm maintenance$2/ha + buffer planting $80/ha + No winter Nitrogen $34	Profit increase from Cash operating increase $199/ha NPV $/ha/yr $19	Reduced water treatment costs Flood protection savings Health cost savings Improved contact recreation Food gathering Improved ecosystem services	

B Sheep and Beef	Action A costs + Trees & sleeves $33/ha	Action A costs + Tree maintenance $6/ha	Soil retention? NPV $/ha/yr $8	Reduced water treatment costs Flood protection savings Health cost savings Improved contact recreation Food gathering Improved ecosystem services	
C Dairy	Action A + Action B + Herdhome $3400/ha	Action A + Action B + Herdhome $136	Profit increase from Cash operating increase $408/ha NPV $/ha/yr $961	Reduced water treatment costs Flood protection savings Health cost savings Improved contact recreation Food gathering Improved ecosystem services	
C Sheep and Beef	8 wire fence and native 15m buffer $4198/ha	Fencing & planting $346 ha – (savings from reduced stock loss + improved health $11) + depreciation?	Soil retention ? Carbon credits? Pollination services? Manuka honey products? Medicines and plants? NPV $/ha/yr $255	Reduced water treatment costs Flood protection savings Health cost savings Improved contact recreation Food gathering Improved ecosystem services	

D **SLUI**	Forestry planting $1690/ha	Opportunity cost of lost productive land $180/ha + Interest on capital Investment (8%)= $135/ha Annual costs ($100/ha most years: Year 4 - $925/ha; Year 6 - $775/ha; Year 8 $1160/ha)	NPV $/ha/yr $234 Avoided flood protection $2/ha + Retention of soil $25/ha + Carbon credits $$/ha ?? *Short term return* increase in property value $5,000/ha *Long term net revenue* (after 26 years) $20,000/ha	Reduced water treatment costs Flood protection savings Health cost savings Improved contact recreation Food gathering Improved ecosystem services Reduced infrastructure damage Improved visual amenity	
E **WWTP**	*LTP $ Amounts* Feilding ($7.8m) Dannevirke ($1.047m) Pahiatua ($1.7m), Kimbolton($0.3m), Longburn ($0.3m), Eketahuna ($0.93m), Ashhurst ($2.1m) PNCC ($20m) Total =$34m *MfE Application $ Amounts* Feilding ($11.3m) Dannevirke ($4.2m) Pahiatua ($1.1m) Kimbolton ($0.3m) Woodville ($1.4m) Foxton ($15m) Total = $33.3m	Annual operating and maintenance (4% EBMP) of $1.3m/yr + Depreciation over 25 years $1.3m/yr + Interest cost (8%) $2.7m/yr		Reduced water treatment costs Health cost savings Improved contact recreation Food gathering Improved ecosystem services Mauri of the river restored? Compliance	E.Coli ? % Nitrogen ? % Phosphorous ? %

To ensure resources are directed to the Actions that achieve the best outcomes for the river, the scale of the operation also needs to be taken into account. For this reason Table 9 provides estimated reductions multiplied by the total hectares in each land use. On a per hectare basis reductions in the loading from horticultural/cropping activities were identified as where the most impact can be made (Clothier, Mackay et al. 2007), however the scale of horticultural/cropping operations in the MRC is not great enough compared to other farming types to have a major impact. Table 9 sets out the expected outcomes from the Actions in the CBA if the expected gains in Table 8 above are applied to the scale at which each operates. This gives an indication of the potential improvements to river water quality if for each Action undertaken. Table 9 also provides an approximate annual cost for each Action (as $ NPV) for the 20 years from 2011 to 2030 the CBA was calculated for.

Table 9: Expected Changes in Loading and Average NPV costs per year

		Base Loading per ha/yr				Total Loading before Action Undertaken				Estimated Reduction in Loading from Action				Cost	
		E.Coli MPN/ha/yr (x10^15)	Sediment kg/ha/yr	Phos kg/ha/yr	Nitrogen kg/ha/yr	E.Coli MPN/ha/yr (x10^15)	Sediment t/yr	Phos t/yr	Nitrogen t/ha/yr	E.Coli MPN/ha/yr (x10^15)	Sediment t/ha/yr	Phos t/ha/yr	Nitrogen t/ha/yr	NPV $m/yr	NPV $/ha/yr
Dairy															
Ha	77022														
Action A		151	4,000	0.6	40	11,630,322	308,088	46	3,081	9,187,954	7,702	35	493	0.6	8
Action B		151	4,000	0.6	40	11,630,322	308,088	46	3,081	10,816,199	30,809	41	1,910	1.5	19
Action C		151	4,000	0.6	40	11,630,322	308,088	46	3,081	10,816,199	30,809	41	2,033	74.0	961
Sheep and Beef															
Ha	365747														
Action A		1,510	9,000	0.75	15	552,277,970	3,291,723	274	5,486	132,546,713	82,293	16	219	2.6	7
Action B		1,510	9,000	0.75	15	552,277,970	3,291,723	274	5,486	132,546,713	164,586	25	329	2.8	8
Action C		1,510	9,000	0.75	15	552,277,970	3,291,723	274	5,486	248,525,087	164,586	129	1,317	93.4	255
SLUI															
Ha	39000														
Action D		1,510	9,000	0.75	15	58,890,000	351,000	29	585	47,112,000	315,900	19	351	9.1	234

Based on a MRC population of 133,000 people Table 10 gives an estimate of what the non-market values would need to approximate for each action to be considered worth undertaking. For example, for Action A, if the non-market benefits associated with a reduction of 7,702 t/ha/yr in sediment, a 35/t/ha reduction in Phosphate and a 493 t/ha/yr reduction in nitrogen across all of the land in dairying were worth more than $91/person/yr in benefits for the river then this action would be viable.

Table 10: Estimate of Benefits to the River, Costs (NPV) and the Amount of Non-market Benefits per person Required to Cover Costs

		E.Coli MPN/ha/yr (x10^15)	Sediment t/ha/yr	Phos t/ha/yr	Nitrogen t/ha/yr	NPV $m	NPV Avg over 20 yrs $m	Non-market value/person $	Non-market value/ha $
Dairy									
Ha	77,022								
Action A		9,187,954	7,702	35	493	12.0	0.6	91	7.8
Action B		10,816,199	30,809	41	1,910	30.0	1.5	226	19.5
Action C		10,816,199	30,809	41	2,033	1,480.6	74.0	11,132	961.1
Sheep and Beef									
Ha	365,747								
Action A		132,546,713	82,293	16	219	52.1	2.6	392	33.8
Action B		132,546,713	164,586	25	329	55.1	2.8	414	35.8
Action C		248,525,087	164,586	129	1,317	1,867.7	93.4	14,043	1212.5
SLUI									
Ha	39,000								
Action D		47,112,000	315,900	19	351	182.9	9.1	1,375	118.7

1.2.4 Applying the Analytic Hierarchy Process to aid Decision-making

As can be seen in Table 9 and Table 10, costs and benefits vary for each of the Actions and cannot be compared directly. Therefore, the Analytic Hierarchy Process (AHP) is used in the following section as a decision aid tool. Using this method options are evaluated in a pairwise fashion to determine their relative rankings for various criteria and the results are mathematically combined to get to overall scores for the alternatives. See Schmoldt et al. (2001) for more detail.

From Table 8 it can be seen that Action C for Dairy is a very expensive option compared with Action B for Dairy for the small benefit in reduced nitrogen leaching. Action C for Sheep and Beef provides significant reductions in phosphate and nitrogen loading to waterways but the annual cost of $93.4m for a 20 year period would be prohibitive for farmers. Therefore, for both Diary and Sheep and Beef 'Action C' has been excluded from the AHP analysis. Ecoli has also not been included as Maximum Possible Numbers (MPN) is not a consistently reliable measure.

The logic of an AHP is to compare each criterion against the other using a consistent scale. The scale determines the importance and allows each pair of criteria to be compared independently of other criteria.

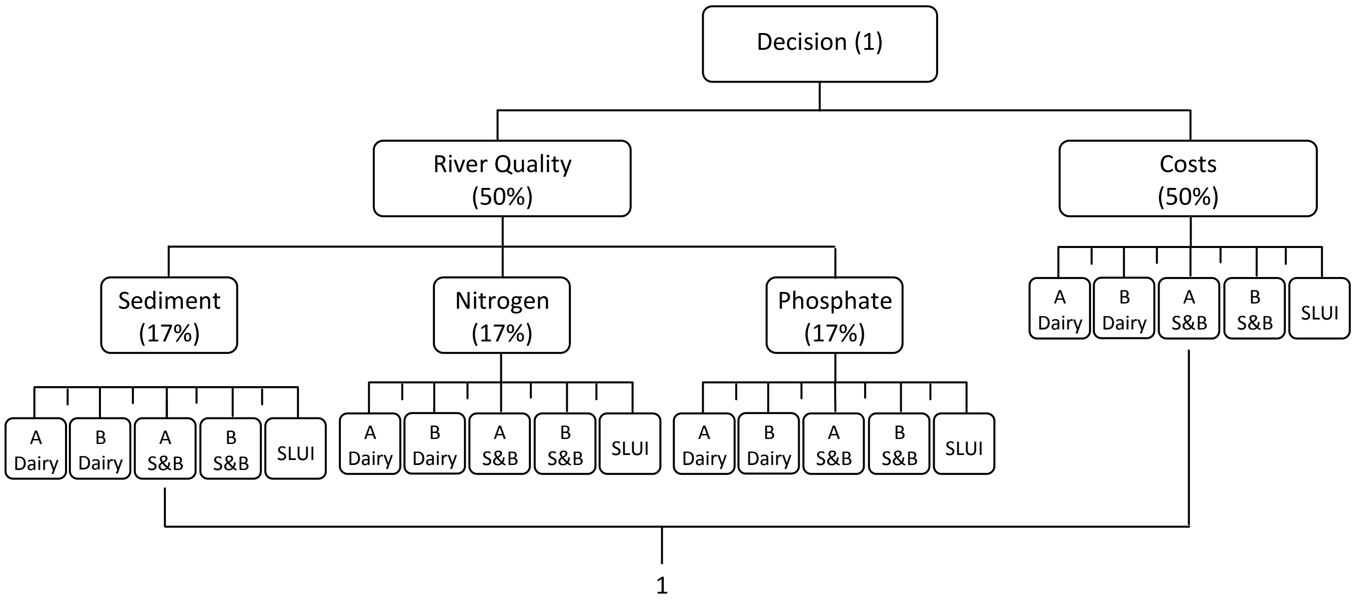
The scale for the MRC comparison is determined by 'tonnes' for each of sediment, nitrogen and phosphorous. It is an assumption of the AHP that impacts are in direct proportion to their values. This means that two tonnes of nitrogen is considered to be twice as polluting as one tonne. In reality it may be possible for a waterway to assimilate two tonnes of nitrogen with no adverse effects and negative impacts are not incurred until a threshold level has been exceeded. For NPV the scale used is dollar costs.

With sediment, nitrogen and phosphorous the goal is to reduce loading to the river so the action that achieves the greatest reduction is preferred over the others. With costs (expressed as $NPV) the reverse situation applies. The action that achieves the lowest cost is preferred over the others. For this reason an index of 1-9 was used for the NPV dollar amounts in the analysis. The lowest cost of $0. 6m for Action A Dairy was assigned an index value of 9. SLUI which had a NPV value of $9.1m was assigned the index value of 1. Costs for the other actions which were between $0.6m and $9.1m were given index values relative to their costs.

For the base run in the decision matrix it was decided that the costs and benefits to the river (reduced sediment, reduced nitrogen loading and reduced phosphate loading) were equally important, therefore, costs were given 50% of the weighting and river improvements an equal 50% weighting. Next in the hierarchy sediment, nitrogen and phosphate reductions were ranked by importance and in the base run considered equal (17% each). The hierarchal decision-making tree used is as shown in Figure 3.

In the graphs that follow the percentage indicates the contribution of each action to the overall goal (measured as 100% and consisting of 50% river quality and 50% costs as in Figure 3).

Figure 3: Decision making Hierarchy for Actions



Using the Base run weightings SLUI is the best option to achieve the goals set. As shown in Figure 4 it rates the highest when all factors are added together.

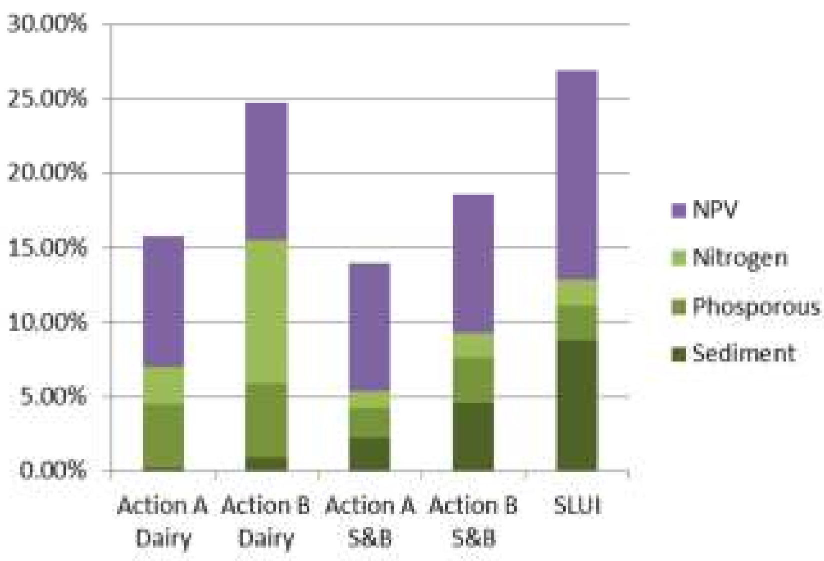


Figure 4: Base Run with Costs and Benefits to the River of Equal Importance

If sediment removal is regarded as twice as important to the health of the river as the leaching of phosphorous and nitrogen then the SLUI option is again the best alternative as shown in Figure 5.

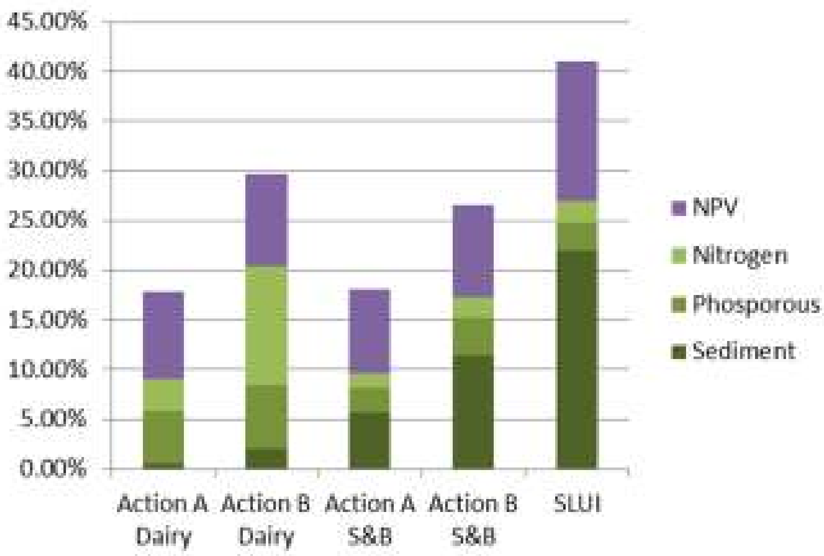


Figure 5: Costs and Benefits to the River of Equal Importance with Sediment twice as important as N and P

Both phosphorous and nitrogen can be limiting in the Manawatū with both taking place in different locations on the same day. Looking at both these options Figure 6 shows that if it is decided that limiting phosphorous is the priority and this is ranked twice as important as nitrogen and sediment removal then SLUI is again preferred. SLUI also has the added advantage of returning a profit from harvesting[5] in a further six to ten year timeframe which is not included in the NPV calculations.

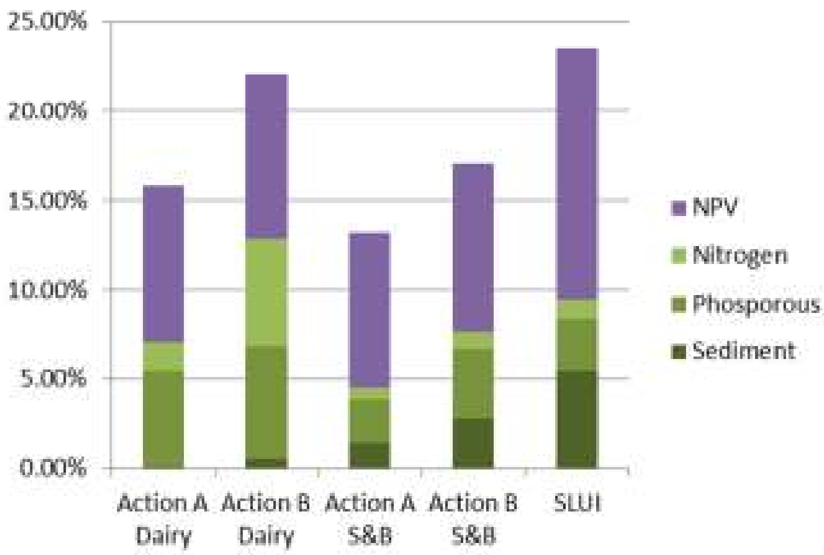


Figure 6: Costs and Benefits to the River of Equal Importance with P twice as important as Sediment and N

If it is decided that limiting nitrogen is the priority and this is ranked twice as important as sediment and phosphorous removal then Action B Dairy is also the preferred alternative as shown in Figure 7.

[5] In a way they minimises sediment loadings.

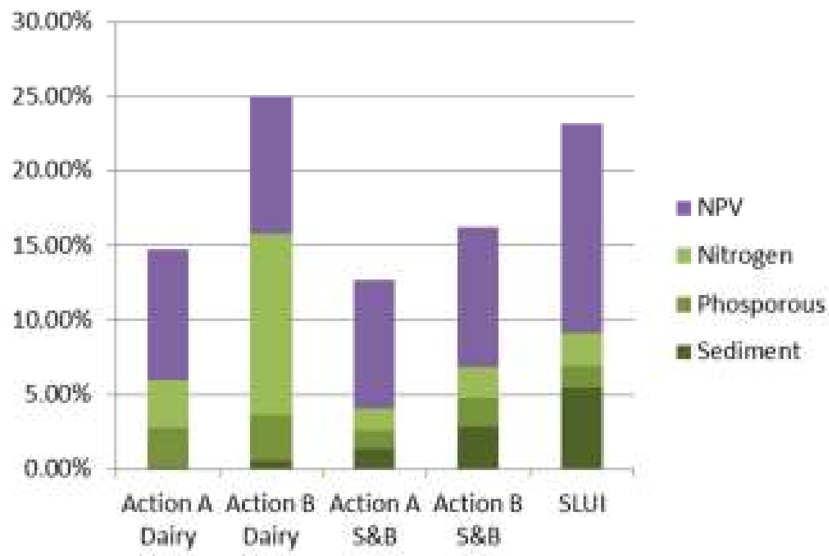


Figure 7: Costs and Benefits to the River of Equal Importance with N twice as important as Sediment and P

2. CONCLUSIONS

As was found with the Waikato River Independent Scoping Study the costs for remedial actions to reduce pollution to waterways are significant. This is a barrier to any of the proposed actions being implemented when using the traditional CBA approach. For the MRC if costs and improvements to water quality are considered to be of equal importance for the MRC then SLUI can achieve the best overall outcome. The SLUI option is also the preferred alternative if sediment is regarded as the critical factor for river health. Action B Dairy is also a good alternative if N removal is considered twice as important as sediment and phosphorous removal.

This analysis draws on the costing used in the Waikato region so it is acknowledged there is likely to be some variation in the MRC. As with the science needed to inform choices the best cost estimates to use are often disputed. Prioritisation has been done using the Analytic Hierarchy Process as this uses relative ranking which can be changed to see what impact it has.

The many well-recognised limitations associated with using CBA for decision-making also apply to this study. From the point of view of the MRC analysis these include:

(1) CBA is a single criteria approach that only uses $ values. Many of the factors that we regard as important for our well-being are not able to be monetised. As a result these factors are treated as having a zero value.

(2) Positive outcomes such as increased ecosystem services that result from soil retention or water purification by wetlands are not counted

(3) Costs are looked at in isolation rather than from the wider economic perspective of the region or nation

(4) Uncertainty and risk are difficult to include

(5) Thresholds and dynamics are excluded

(6) Interest rates in the real world fluctuate with the cost of capital and therefore vary overtime rather than remaining fixed

(7) The interest rate used can become decisive for the whole analysis. When calculating the NPV a high interest rate minimises long term costs and benefits. This does not encourage taking a short term loss to achieve a long term economic strategy.

Appendix A Capital Costs and Operating Costs

For the CBA the decision was made to use farm costs as per the WRISS, where possible, to provide consistency and because the modelled dairy farm profit change was based on these costs.

Error! Reference source not found. (NIWA, 2010 Appendix 10, Table 4) summarises the capital costs and annual operating costs applied.

Table A 1: The capital costs and annualised operating costs for on-farm actions within the Waikato River catchment

Farm type	Action	Capital cost, $/ha	Annualised cost, $/ha/year
Dairy[1]	Single-wire fence	47	5
	Enlarged effluent ponds	83–123	7–10
	Fencing out wetlands	68	22
	Laneway berms	10	2
	Herd shelter	3,400	136–270
	Change to organic dairy	Minor	184
	Planting 5 m riparian buffers	686	80
Sheep-beef[2]	Single-wire fence	146–220	12–18
	Single-wire fence and poplars	200–301	16–24
	8-wire fence and natives, 5 m buffer	1,427–2,141	123–177
	8-wire fence and natives, 15 m buffer	2,799–4,198	264–346

[1]Varies between model farm types depending on soil type.
[2]Varies between model farm types depending on assumed stream density.

Source: NIWA, 2010; Appendix 10: Faecal Contamination, Table 4

Appendix B Methodology for Estimating Land use change for the Manawatū River Catchment

Land use data for 1990 and 2008 was obtained for the catchment using the Land Use and Carbon Analysis System (LUCAS) satellite imagery for land-use classes (Ministry for the Environment, 2010). The total change in ha for each land-use was apportioned equally to each year between 1990 and 2008. The same rate of change was assumed for 2009 and 2010. The annual effective hectares in dairying was obtained for each TLA from the Livestock Improvement Corporation and reduced to reflect the proportion of dairying in the catchment. Grassland was reduced by the ha of dairying to get the ha in sheep/beef/deer farming.

Land Use and Carbon Analysis System (LUCAS)

GIS Land use maps for New Zealand were constructed for 8 different land-use classes for the years 1990 and 2008.

The land use classes are:

1. Cropland (perennial and annual)
2. Grassland (high producing and low producing)
3. Other (settlements; montane rock/scree; bare ground)
4. Water (lakes, rivers)
5. Wetland (herbaceous and /or non-forest woody vegetation periodically flooded; estuarine/tidal areas)
6. Woody Grassland (grassland with tall trees such as golf courses, small (<30% cover) erosion or riparian plantings, grassland with shrubs not expected to reach >5 metres over next 30-40 years)
7. Natural Forest (forest on conservation land, tall, non-planted forest, broadleaved hardwood shrubland, manuaka/kanuka shrubland)
8. Planted Forest (radiata pine, Douglas-fir, eucalypts, or other planed species; harvested areas within forest land assumed for replanting in the future)

For the Manawatū River catchment area the change in land use between 1990 and 2008 in each of these classes was as follows:

	Total 1990 (ha)	Decrease (ha)	Increase (ha)	Total 2008 (ha)
Cropland	6,240.99	0	51.9075	6292.9
Grassland	449,978.08	7,646.51	1158.46	443,490.02
Other	7,284.24	70.90	10.42	7,223.76
Water	2,337.91	0	0	2,337.91
Wetland	241.09	10.73	0	230.35
Woody Grassland	31,974.75	2,116.57	1494.77	31,352.94
Natural Forest	81,996.64	593.19	0	81,403.45
Planted Forest	8,392.99	181.87	7904.23	16,115.35
Unexplained	19.51			19.51
	588,466.19	10,619.77	10619.77	588,466.19

Dairying Hectares

The areas of land in dairying for the period 1990-2010 was calculated as follows:

1. Effective ha in dairying for each of the 4 TAs (MDC, PNCC, HDC, and TDC) was obtained from LIC statistics data (Livestock Improvement Corporation and Dairy New Zealand, various). The percentage of dairying in the Manawatū catchment was estimated using the Land Use New Zealand (LUNZ) dataset for 2003. LUNZ was initially developed to provide land-use information for the Catchment Land Use for Environmental Sustainability (CLUES) project (Woods et al 2006). LUNZ uses AgriBase, LCDB2 and LENZ data improved with local landscape understanding (Robert Gibb, pers. comm. October, 2010).
2. For each TA, the number of hectares in dairying in the catchment as a percentage of the TA total was calculated.
3. The2003 percentage (from 2) was applied to the TA LIC effective ha in dairying to estimate for each year the effective ha of dairying within the catchment for 1990-2010.
4. The hectares of land (from 3) was summed to get the catchment ha for each year from 1990 to 2010.

Sheep/Beef/Deer

For each year the area in Grazing was reduced by the effective ha in dairy the get the ha in Sheep/Beef/Deer farming.

Forestry Hectares

An attempt was made to get the trend in exotic forestry for the catchment from the *National Exotic Forest Description* (NEFD) data for the period 1991 to 2010 (MAF, various). The methodology set out below was followed but the trend data not used due to the degree of inconsistency between datasets.

NEFD statistics give “ the net stocked area of the planted production forest estate; that is, all forests planted with the primary intention of producing wood or wood fibre as at the 1 April each year” (MAF, 2009). The areas of land in exotic forestry for the catchment for the period 1991to 2010 was calculated as follows:

1. Ha in forestry for each of the 4 TAs (MDC, PNCC, HDC, and TDC) obtained from NEFD statistics.
2. To calculate forestry in the catchment the total catchment ha in ‘Planted forest’ as a percentage of the total TA hectares in ‘Planted forest’ in 1990 and 2008 was estimated from the LUCAS dataset.

The total ha in exotic forestry in NEFD and LUCAS for New Zealand overall lined up reasonably well for 1990 and 2008. The LUCAS hectares are higher in both instances by about 20%. This may be explained by the inclusion of cut-over forestry in LUCAS which is not included in the NEFD. At the TA level there was a significant difference between the total NEFD ha of exotic forestry for MDC, PNCC, HDC and TDC and the LUCAS figures. In 1990 the NEFD total was 6,373 ha compared to 15,197 ha in LUCAS (i.e. only 42% of LUCAS). In 2008 the NEFD total was 29,963 ha compared with 34,835 ha in 2008 (86% of LUCAS). The NEFD data is from surveys of forest owners and consultants who own or manage planted production forests, complied by the National Forest Association and Ministry of Agriculture and Forestry. Given the survey base of the data a possible explanation for this large discrepancy is an under reporting of forestry in 1990 NEFD. Applying the trend from NEFD was therefore considered spurious and not attempted.

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