BEFORE WAIKATO REGIONAL COUNCIL
HEARINGS PANEL

UNDER	the Resource Management Act 1991 (**RMA**)
IN THE MATTER OF	Proposed Plan Change 1 to the Waikato Regional Plan and Variation 1 to that Proposed Plan Change: Waikato and Waipa River Catchments

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Timothy DENNE

PRIMARY EVIDENCE ON BEHALF OF THE AUCKLAND/WAIKATO & EASTERN REGION FISH AND GAME COUNCILS ("FISH & GAME")

SUBMITTER ID: 74985

Hearing Block 1

Dated: 15 February 2019

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1. QUALIFICATIONS AND EXPERIENCE

1.1 My full name is Timothy Denne.

1.2 I am an economist and an owner and director of Covec Ltd, an Auckland-based economics consultancy. I have worked at Covec for 15 years and have been a director since June 2005. I am also an owner of a separate consultancy, Resource Economics Ltd.

1.3 I have a PhD in resource economics from the University of London (1988) and an MSc (Hons) in Resource Management from the University of Canterbury (1983).

1.4 I have worked as an economist for over 30 years in New Zealand, the UK and the USA, particularly on the application of economic theory and analysis to resource management issues. In addition to my current employment, this has included working in UK-based consultancies, central and regional government (in NZ), policy think-tanks and in university research posts.

1.5 Of relevance to this statement, my work has included cost benefit analyses (CBAs) of improvements in water quality, literature reviews of non-market values for water quality evaluation, and CBAs of investments in new water, wastewater and stormwater infrastructure.

1.6 I have also led CBAs and other economic analyses to assist decisions relating to marine water quality, energy supply, greenhouse gas emission reductions, air quality, mining projects, transport investments, waste management, pest management, housing supply and health (disease prevention). I have led studies to identify non-market values using stated preference survey techniques.

1.7 I have extensive experience in the design and application of economic instruments to environmental policy, including advising Environment Waikato on matters which include the potential use of economic instruments to achieve resource management outcomes under existing legislation.[1]

1.8 I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it. I confirm that the issues addressed in this brief of evidence are within my area of expertise.

1.9 I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed. I have specified where my opinion is based on limited or partial information, and identified any assumptions I have made in forming my opinions.

1.10 In addition, in preparing my evidence I have reviewed the following relevant documents:

(i) The Section 32 Evaluation Report (Waikato Regional Council 2016);[2] and

(ii) The Section 42A Report (Waikato Regional Council 2019);[3] and

(iii) The scenario modelling reports containing the economic analysis (Doole *et al*. 2015a[4] and 2015b[5]).

[1] In Denne T (2005) Economic Instruments for the Environment. Report for Environment Waikato. Covec.

[2] Waikato Regional Council (2016) Proposed Waikato Regional Plan Change 1 – Waikato and Waipā River Catchments Section 32 Evaluation Report.

[3] Waikato Regional Council (2019) Section 42A Report Proposed Waikato Regional Plan Change 1 – Waikato and WaipāRiver Catchments Part A and Part B.

[4] Doole G, Elliott S, and McDonald G (2015a) Economic evaluation of scenarios for water-quality improvement in the Waikato and Waipa River catchments. Assessment of first set of scenarios. 24 August 2015. Prepared for the Technical Leaders Group of the Healthy Rivers/Wai Ora Project.

[5] Doole G, Elliott S, and McDonald G (2015b) Evaluation of scenarios for water-quality improvement in the Waikato and Waipa River catchments. Assessment of second set of scenarios 24 September 2015. Prepared for the Technical Leaders Group of the Healthy Rivers/Wai Ora Project.

2. **SCOPE OF EVIDENCE**

2.1 My evidence will deal with the following issues:

2.1.1 A review and critique of the economic analysis, including its failure to include benefit analysis and its use of input-output analysis;

2.1.2 A brief explanation of alternative approaches, and particularly the use of cost benefit analysis (CBA); and

2.1.3 A critique of the decision criteria used and particularly the adoption of a ‘realistic’ criterion rather than examining optimal or efficient outcomes.

3 SUMMARY STATEMENT

Presentation of cost data in Economic Analysis

3.1 Doole *et al.* (2015b) analysed the economic impacts of water quality improvements in the Waikato and Waipā catchments, defined as different percentage achievements of an aspirational scenario (Scenario 1), relative to the status quo. They suggest increasing marginal costs of improvement, with a steep increase from 25% of Scenario 1. However, this conclusion somewhat reflects the way the data are presented. Unequal steps were used on the x-axis (Figure 1 on page 8). If presented with equal steps, there is no "*step change*" in the cost curve which might be used to justify a targeted level of improvement based on costs alone.

Costs based on constrained land use change

3.2 The analysis of catchment level costs has assumed constrained[6] land use change in most instances, and entirely for analysing 10% and 25% shifts towards Scenario 1. Other analysis suggests significant land use change can occur within ten years. Not presenting results for unconstrained land use change is a significant omission which inflates estimated costs.

The economic analysis is inappropriate

3.3 The economic analysis undertaken to date is inappropriate for the decisions being made, because:

- It has used a cost analysis methodology which assumes a static economy not able to reallocate resources after a forced change in land use activity. This considerably over-estimates the level of costs.
- It does not analyse the benefits in monetary terms in a way which would allow comparison and analysis of whether making greater early progress in improving water quality would have greater net benefits than the rate of change proposed.

Use of Input-Output Analysis (IO)

3.4 IO analysis models the relationships between industries and activities in the economy, based on historical data expressed as fixed "multipliers". This is extremely short-run analysis. IO analysis measures the immediate impact only, which allows no readjustment of the economy as might happen when jobs are lost in one industry and people find work in another. For example, if there is a shift in land use from dairy to forestry

[6] The extent of land-use change possible was constrained to lie within the range observed over the last forty years.

which employs fewer people per land area, IO analysis assumes employment, income and expenditure are reduced and that the lost labour and other resources are then idle. This leads to significant over-estimates of impacts.

3.5 Other economic analysis techniques, such as general equilibrium (GE) and cost benefit analysis (CBA) make different assumptions, eg. assuming prices change such that all resources (including labour) are reemployed in other sectors (or locations). These types of analyses are more appropriate for understanding effects, especially when they extend beyond one year, which is clearly the case here.

Failure to undertake Benefit Analysis in monetary terms

3.6 The economic analysis does not include benefit analysis. Cost analysis alone does not provide a sufficient basis for assessing whether any level of environmental quality is preferred.

Potential Use of Cost Benefit Analysis

3.7 A non-market valuation study undertaken in 2014 estimated the benefits for the whole Waikato catchment of a reduction in median nitrogen (N) and total phosphorus (P).[7] The study quantified benefits on ecological health and the associated values to users (eg. for recreation) and non-users (those who value the fact that it is more pristine). The medium value of a 30% reduction in N and P is estimated at $22 million per annum, $6 million of which is to the Waikato Region. These estimates do not include several benefit categories, including water clarity (valued by recreational users) and reductions in infections from *E coli*. In addition, downstream benefits for wetlands were not included, and so the total benefit is under-estimated.

3.8 It is not possible to make a direct comparison between the 30% reduction in N and P analysed in this 2014 study, and the proportion achievement of Scenario 1 as used for cost analysis. However, the analysis shows that monetary benefits estimated from a limited component of total benefit, is in the same order of magnitude as the estimated costs for the 10% or 25% shift towards Scenario 1 (assuming constrained land use

[7] Phillips Y (2014) *Non-Market values for fresh water in the Waikato Region: a combined revealed and stated preference approach.*Waikato Regional Council Technical Report 2014/17.

change). This suggests that taking more ambitious steps to improve water quality, has the potential for positive net benefits.

3.9 In the absence of benefit analysis as an input to a CBA, and if the modelling is relied upon to conclude a 10% shift toward Scenario 1 is optimal, as distinct from, for example a 15%, 25%, 50% or 75%, I do not agree with the Section 42A Report that the "*modelling undertaken is fit for purpose*".[8] The issues I outline with this modelling mean that it is not only inadequate for the purpose, it should be disregarded, except in relation to its findings on catchment level profit lost which is a suitable estimate of costs (albeit with constrained land use change). There appears to be little economic justification for the 10% shift towards Scenario 1 as a maximum feasible objective in the first ten years.

Selection Criteria

3.10 In addition to the analysis of Doole *et al.* (2015b), the Collaborative Stakeholder Group (CSG) adopted criteria for policy selection, which include the identification of options which are "realistic" to implement and with "realistic" timeframes. Whether the proposed policy is realistic appears to have been used to limit improvements to 10% achievement of Scenario 1 as a ten-year target, with more significant improvements pushed out to a staged achievement of an 80-year target.

3.11 This application of this criterion partly reflected the time lag between reduced farm-level inputs and water quality outcomes because of soil and groundwater transport processes, and partly costs. The limits based on costs appeared to include the limited potential and high costs of mitigation options by the dairy and horticulture sectors, rather than assuming land use change could occur to achieve more stringent targets. The scenario modelling already included the costs of land use change (based on existing technology and prices and some constraints to land use change). Not only does imposing an additional "realistic" criterion risk over-weighting the effects of short-run assumptions in the cost analysis in the Round 2 modelling, other research suggests significant land use changes can occur within ten years.

[8] At [288].

4 ECONOMIC ANALYSIS

4.1 Fish & Game submits[9] that the economic analysis is flawed on the basis that it assumes all reductions in nutrient loss will incur economic cost, without taking account of the economic benefits associated with improved water quality. As a result they suggest the economic modelling in Part C of the Section 32 Report should not be relied upon. I agree with this statement and have additional concerns.

4.2 Below I set out three concerns I have with the economic analysis:

(1) The way the cost data are presented to suggest a justification for a lower level of ambition;

(2) The use of input-output analysis leading to an over-estimate of costs; and

(3) The failure to include quantification of benefits in monetary terms.

Presentation of cost data

4.3 Doole *et al*. (2015b) analysed the economic impacts of scenarios for water quality improvements in the Waikato and Waipā catchments. The scenarios were defined as different percentage achievements (10, 25, 50, 75, and 100%) of an aspirational scenario (Scenario 1), relative to the status quo. Scenario 1 is characterised by substantial improvement in water quality for swimming, taking food, and healthy biodiversity.

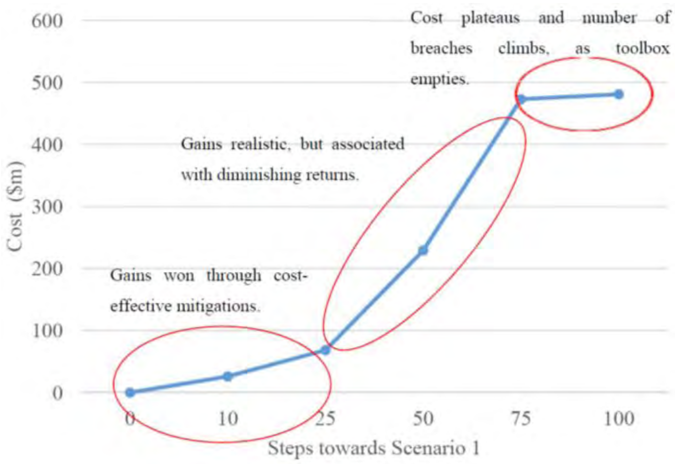
4.4 Water quality improvements are achieved through a mixture of land use change, reduced farming intensity and mitigation measures which include stream fencing, effluent management, erosion control and edge-of-field mitigations (eg bunds, sediment traps, and wetlands). The modelling included:

- **fixed** land use in which all reductions in emissions have to be based on mitigation measures possible with current land uses;
- **constrained** land use change, in which the extent of land-use change possible was constrained to lie within the range observed over the last forty years; and
- **unconstrained** land use, in which any land use could occur.

[9] PC1-11007 (Fish & Game original submission paragraph C.2.2.11).

4.5 Doole *et al.* analysed the economic implications of these scenarios at the farm, catchment, regional, and national scales. Figure 1 shows the estimated costs of different percentage achievements of Scenario 1 based on the reduction in catchment-level profit, assuming constrained land use change. The authors suggest there is a relatively low initial increase in costs per % improvement in water quality (steps towards Scenario 1), but from 25% of Scenario 1, costs rise significantly, before slowing again from 75%. However, this conclusion somewhat reflects the way they have presented the data, with the units on the x-axis (Steps towards Scenario 1) being larger % changes as you go from left to right (the sizes of the steps are 10%, 15%, 25%, 25% and 25%).

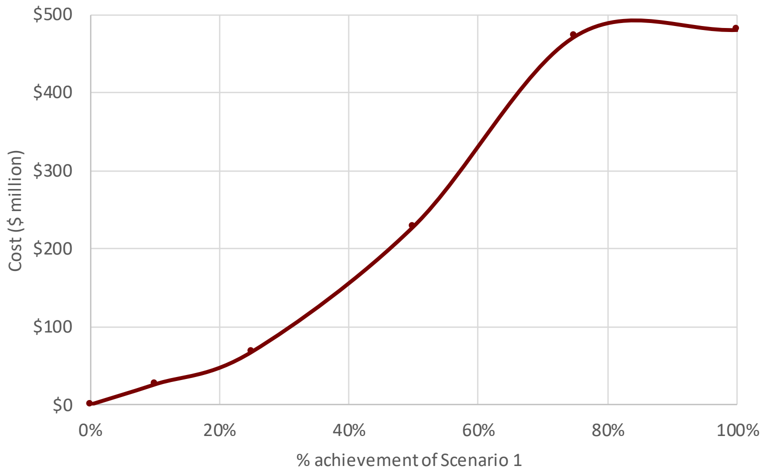
Figure 1 Cumulative costs of percentage achievement of Scenario 1 with constrained land-use change



Source: Doole *et al.* (2015b)

4.6 Figure 2 shows the same data using equal (20%) steps on the x-axis and a smoothed line. The data still show increasing marginal costs, but (apart from at 75%) there is no clear step-change in the data that (in the absence of data on benefits) might be used to define a suitable point at which to limit improvement effort and costs.

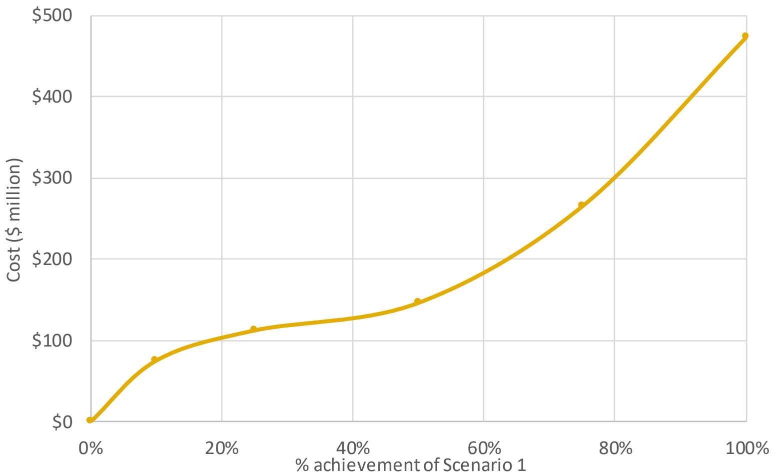
Figure 2 Cumulative costs of % achievement of Scenario 1 with constrained land-use change (revised figure)



Source: adapted from Doole *et al.* (2015b)

4.7 Figure 3 shows a graph of the results of an alternative analysis provided by Doole *et al.* in which land use is fixed for the 10% and 25% of Scenario 1 but unconstrained for 50%, 75% and 100% movements. This shows higher initial costs (because of the land use change constraints) and diminishing marginal costs, which do not rise until after 40% of Scenario 1 is achieved.

Figure 3 Cumulative costs of % achievement of Scenario 1 with a combination of fixed and unconstrained land-use change



Source: adapted from Doole *et al.* (2015b) Table 7

4.8 The way the data are presented, and the assumptions, make a large difference to the shape of the curve. Estimated costs are lower with land use change unconstrained, and are higher if land use continues as currently, and with targets met through the use of mitigation measures.

No assumptions result in a disjunction in the cost curve which might justify a low targeted level of water quality improvement defined on the basis of costs alone.

4.9 The main results are presented using constrained land use.[10] However, I note that other research suggests significant land use change can occur within time frames of less than ten years in response to changes in relative prices.[11] Similar significant shifts might be expected to occur in response to other regulatory interventions. The Doole *et al.* analysis does not present the results of unconstrained land use change for 10% or 25% shifts towards Scenario 1. This is a major omission and excludes results which would have been expected to show significantly lower costs.

Input-Output Analysis

4.10 The catchment level model estimates the impacts on farm-level profits. It uses assumptions consistent with prices being based on opportunity costs of production. These are appropriate estimates of costs. However, the impacts on profit were used to provide inputs to input-output (IO) modelling, and to estimate impacts on value-added and employment (Table 1).

Table 1 Impacts of steps towards Scenario 1 with constrained land use change

% of Scenario 1	Catchment-level profit ($m)	Value-added ($m)[a]	Employment (employee count)[a]
10%	-$26	-$101 (-$212)	-1,198 (-2,276)
25%	-$68	-$164 (-$339)	-1,954 (-3,742)
50%	-$229	-$221 (-$438)	-2,389 (-4,684)
75%	-$473		
100%	-$481		

[a] Impacts on whole Waikato region and on New Zealand (in brackets)
Source: Doole *et al.* (2015b)

4.11 The IO analysis models the relationships between industries and activities in the economy, based on historical data eg. the value of products purchased from all other industries as inputs to production by one specific industry, such as dairy farming. The relationships between different industries are defined by a set of "multipliers", which are the

[10] In which the extent of land-use change possible was constrained to lie within the range observed over the past 40 years.
[11] Kerr S and Olssen A (2012) Gradual Land-use Change in New Zealand: Results from a Dynamic Econometric Model. Motu Working Paper 12-06. Motu Economic and Public Policy Research.

coefficients used to estimate the impacts on activity in one industry following a change in another.

4.12 IO analysis provides a snap-shot in time and the multipliers are fixed. This means, if activity and employment in one industry is assumed to reduce, all related activities and employment are assumed to reduce also, including those supplying the industry and those using the outputs, at the same ratio as the snapshots used. When fewer resources are required, these resources are assumed to be subsequently idle.

4.13 Doole *et al.* (2015b) justify the use of IO analysis on it being the most widely-applied method for estimating the regional impacts of environmental policy. They note IO's primary advantage is that it describes the complex interdependency between different sectors within an economy, allowing the consideration of numerous flow-on relationships arising from a change in current economic activity. However, the widespread use of IO has been widely criticised also.

4.14 An important criticism is the use of static multipliers, which can lead to greatly exaggerated estimates of effects when a change occurs in any sector.

4.15 Doole *et al.* (2015b) note:

4.16 "*As with all modelling approaches, IO analysis relies on certain assumptions for its operation. Among the most important is the assumption that the input structures of industries (i.e. the mix of commodities or industry outputs used in producing output for a specific industry) are fixed. In the real world, however, these 'technical coefficients' will change over time as a result of new technologies, relative price shifts causing substitutions, and the introduction of new industries. For this reason, IO analysis is generally regarded as most suitable for shortrun analysis, where economic systems are unlikely to change greatly from the initial snapshot of data used to generate the base IO tables. This further justifies the selection of this method for the regional-level economic analysis, given that the catchment-level model presented above also represents a snapshot of reality that is based* *heavily on current prices, technologies, management practices, and knowledge of biophysical relationships*. …"

4.17 Assumptions of static prices and technologies in the catchment model (HRWO) do not justify the more wide-ranging static assumptions of IO analysis. The price assumptions are used as inputs to analysis and are used to estimate the costs. The model also analyses the value of output, and profits, from future land uses.

4.18 The assumptions of current prices and technologies in the catchment (HRWO) model, are an appropriate simplification, in the absence of certainty over future changes in (real) prices, or of technological development. The assumptions are still consistent with the economic principle that all costs are opportunity costs and that, in competitive markets, prices reflect the opportunity costs of supply. I have not analysed the specific input assumptions to this modelling, but, as stated, the approach is appropriate.

4.19 In contrast to the HRWO catchment level modelling, the results from using the static multipliers in the IO analysis are unrealistic because this approach does not take account of opportunity costs. It assumes that when fewer resources are required the resources that are freed up are consequently idle. For example, if there is a shift in land use from dairy to forestry and forestry employs fewer people per land area, IO analysis assumes total employment, income and expenditure reduces by fixed amounts defined by the multipliers. This does not allow the economy to change structure as might happen when, for example, jobs are lost in one industry and people find work in another. This leads to significant over-estimates of impacts.

4.20 Other economic analysis techniques make different assumptions. For example:

- General equilibrium (GE) models incorporate "closure rules" which enable the modelled economy to reach a new equilibrium eg. these models will often assume the level of employment is fixed and that prices change so that all resources (land, labour, capital) are reallocated to new activities.

- Cost benefit analysis (CBA) assumes all resources, including land and labour, are priced at their opportunity cost which reflects the value they would obtain in their next best use. For example, the wages paid workers in the dairy industry are priced just above what they could obtain by working in another. The implication is that all resources are assumed to be re-employed following land use change.

4.21 Effectively IO analysis is assuming that all other sectors and activities are already maximising activity so there is no possibility of expansion if resources are made available from land use closure.

4.22 Paul Gretton of the Australian National University and former Assistant Commissioner at the Australian Productivity Commission, produced a note on the uses and abuses of IO tables.[12] While he suggests IO data and tables can provide valuable information about the structure of economies and for reporting and analysing the industrial structure of an economy, he suggests there are major limitations to their usefulness for predictive purposes.

4.23 Reflecting these concerns, the NZ Treasury asserts that economic impact analysis (EIA), such as IO analysis, which measures impacts on economic activity "*can provide useful contextual information for decision-makers, but it is not suitable as a tool for measuring the balance of costs and benefits of a decision to society*."[13]

4.24 In contrast to IO, cost benefit analysis (CBA) does not measure any downstream impact (through to other sectors of the economy). The impacts on farm-level profit would be regarded as capturing the full extent of costs. Generally, this is appropriate, and consistent with the assumptions used in GE analysis. For example, CBA assumes labour is priced (and workers are paid) because they could be employed

[12] Gretton P (2013) On input-output tables: uses and abuses. Productivity Commission Staff Research Note. Australian Government.
[13] NZ Treasury (2015) Guide to Social Cost Benefit Analysis.

elsewhere in the economy. Effectively, this assumes labour is 100% reemployed.[14] In addition, CBA does not assume multiplier effects because markets are assumed to be competitive. Suppliers to dairy farms price their output at the opportunity costs of supply (what they could obtain by selling their output elsewhere), and although suppliers will make profits, there are 'normal profits' ie. what would be required by any firm to remain in business.

4.25 Under these assumptions, the first-round effects (eg. Doole *et al.*'s estimates of impacts on farm profits) capture all the (net) benefits of a business activity, as well as all the costs of business closure.[15] Multiplier effects only arise when there are market inefficiencies and resources are not priced at their opportunity costs of supply. Although markets are not completely efficient in practice, assuming an efficient market in which resources are reallocated represents a better first approximation of reality than assuming no resource reallocation, especially when considering impacts over multiple years.

4.26 As noted above, Doole *et al.* suggest IO analysis is best suited to short-run analysis. But this is extremely short-run analysis, ie the immediate (overnight) impact, which allows no readjustment of the economy. For PC 1, the options being considered are focussed on outcomes in ten years and beyond. I understand the objective of the policy is to have a long-term improvement in water quality in the Waikato, involving long-run land use changes and mitigation measures with long-run impacts on water quality. As noted in the Section 32 Report, "*water-quality response timeframes range from immediate to many decades depending on the mitigation, the contaminant, the location, and the receiving water body*."[16]

4.27 Analysis which took account of the potential for the economy to readjust after a policy change, and assuming that the economy is relatively efficient, would be consistent with the assumptions used in a CBA. This would include:

[14] Alternative assumptions can be made in analysis where or when there is high unemployment. Typically this is done by assuming the opportunity costs of labour are lower than market prices; under these circumstances, the effective surpluses to society of current activities (such as dairy farming) would be higher and the losses from closure would be greater.
[15] See discussion in NZ Treasury (2015) Guide to Social Cost Benefit Analysis.
[16] Waikato Regional Council (2016), p78.

- an analysis of costs based on the impacts on abatement measures and catchment-level profits only (Table 1); and
- no (or little) net impact on employment, on the assumption that people will find new work.

5 COST BENEFIT ANALYSIS

5.1 The economic analysis methodology relied on for PC 1 examines the costs of different levels of river water quality, but not the benefits. Cost analysis provides only one side of the equation and does not provide a sufficient basis for assessing whether any level of environmental quality is preferred, in terms of the impacts on regional wellbeing.

5.2 The PC1 Section 32 Report identifies the approach taken to assessing costs and benefits. The *benefit* analysis is undertaken in qualitative (descriptive) and semi-quantitative (percentage changes in pollutant concentrations) but not in monetary terms. There has been no obvious attempt to undertake a full cost benefit analysis (CBA), and the reports by Doole *et al.* do not provide this information.

5.3 A report by the Technical Leaders Group (TLG) used the results of experts' workshops to assess the direction and size of changes in economic, environmental and other outcomes.[17] The results were presented in trend wheels which showed differences between the scenarios. These have the potential to be misleading because the changes in indicators (eg. the difference between scenarios in indicators of abundance of fish species and in value added) are placed on the same scale in a way that might imply equivalence to the differences. CBA has significant advantages over any partial or full multi-criteria analysis such as the trend wheels; it provides a rationale for, and empirical data to justify, the relativities between different effects (eg cost vs water quality outcomes). However, I acknowledge CBA depends on available data.

5.4 Several studies have examined the monetary value of improvements in water quality in New Zealand waterways. These take account of the benefits of increased use value of waterways, eg. for recreation and for

[17] Wedderburn L and Coffin A (2016) Integrated Assessment One: Assessment of Scenarios from modelling round one. Report No. HR/TLG/2015-2016/6.2

"non-use", or for example, people's willingness to pay (WTP) to know waterways have improved in water quality and that they support increased ecosystem health.

5.5 Marsh and Mkwara (2013)[18] reviewed literature on non-market values for freshwater to provide inputs to a study of the costs and benefits of improvements in water quality for the Waikato River. The authors suggest that the values they compiled are "*estimated for specific changes at particular sites*" but that "*none of the values … are suitable for transfer to assess the impact of different central and regional government water quality policies on non-market values in the Waikato*". The reason for this was because the available results were believed to be from sites with unique characteristics, which meant the values could not be readily transferred for use elsewhere.

5.6 Building on this concern, a new non-market valuation study was carried out to provide information on the potential impacts of setting freshwater objectives and limits in the Waikato River Catchment.[19] The study examined the benefits of changes to water quality relating to water clarity, human health risk and ecosystem health.

- Water clarity was based on a black-disc measure, measured in metres. Survey respondents were also provided with pictures of water fitting the different categories.
- Human health risk was based on the E coli counts (at the 95th percentile), converted to expected number of infections per 1,000 people from primary contact.
- Ecological health was based on total N and P but using less technical descriptions (Table 2).

Table 2 Classification of ecological health

Category	Levels of nutrients and algae	Suitability for sensitive species
Good	Low	Very suitable
Fair	Moderate	Usually suitable
Poor	High	Sometimes unsuitable
Very poor	Very high	Unsuitable

Source: Phillips (2014)

[18] Mash D and Mkwara L (2013) *Review of Freshwater Non-Market Value Studies* University of Waikato.
[19] Phillips (2014).

5.7 The non-market values assessed in the study included benefits of recreation and cultural use, option values for future use, and non-use or existence value. The study used *revealed* and *stated preference* techniques to develop values of improving water quality, as follows:

- The revealed preference (RP) analysis examined where and when people use fresh water for recreational or cultural activities, and a survey was used to find out the reasons for liking or disliking a site. The data were used to determine what features influence site visits, to calculate travel costs, and infer a minimum value of a recreation trip.

- The stated preference (SP) analysis used a survey and choice modelling, particularly to examine the non-use portion of non-market values.

5.8 Results per household using a joint RP-SP model are shown in Table 3. These values represent the household willingness to pay (WTP) to improve water quality to the levels shown from zero metres of clarity, high levels of infection and very poor ecological health. Values are shown for users, ie. those who visit the river for recreational purposes, and non-users. Non-use values include existence value, ie the WTP for knowing that the environment is (more) pristine. However, for benefit analysis of interventions (ie. changes to water quality objectives and limits), only the ecological health values were used.

Table 3 Values (WTP per household per year) for different attributes

Attribute	Level	User	Non-user
Clarity (m)	0.2	$4.47	$3.54
	0.6	$15.37	$12.17
	1.1	$32.64	$25.85
	1.6	$53.98	$42.75
	2.5	$102.64	$81.28
	3.5	$172.15	$136.33
Infections (infections per 1,000 people from primary contact)	1 (good)	$169.15	$133.95
	10 (fair)	$163.13	$129.19
	50 (poor)	$94.91	$75.16
	100 (very poor)	$21.12	$16.72
	300 (very poor)	$2.16	$1.71
Ecological health	Poor	$46.12	$36.52
	Fair	$208.84	$165.38
	Good	$227.18	$179.91

Source: Phillips (2014)

5.9 The benefits for the whole Waikato catchment were estimated for a 30% reduction in median nitrogen (N) and total phosphorus (P). This is estimated to result in the proportion of sites defined as "good" ecosystem health increasing from 4% to 15%. The quantified impact of reductions in N and P on water clarity *via* reductions in suspended chlorophyll levels is unknown, and was not included in analysis. Reductions in N & P would not affect levels of infection and so those impacts were also excluded from the benefits. So these estimates do not include the improvements in water clarity which are valued by recreational users and reductions in infections from changes to levels of *E coli*. However, I note the description of the benefits of Scenario 1 includes improvements in water clarity and reductions in *E coli*; this means the overall benefit measured by Phillips (2014) is expected to be understated relative to the effect of Scenario 1 with a similar level of reduction in N and P.

5.10 The estimated annual benefits of the resulting improvement in water quality are shown in Table 4 for the Waikato and New Zealand as a whole, for users and non-users, and for different estimates of the number of users. The total value of a 30% reduction in N and P has a medium estimate of $22 million per annum, $6 million of which is to the Waikato region.

Table 4 Total value ($ million) of water quality improvement per year for different estimates of the total number of users

Region	User / Non-user	Low	Medium	High
Waikato	User	$4.1	$5.3	$5.8
Waikato	Non-user	$1.2	$0.9	$0.8
Waikato	Total	$5.3	$6.2	$6.6
All	User	$7.4	$12.0	$19.7
All	Non-user	$11.5	$10.4	$8.6
All	Total	$18.9	$22.4	$28.3

5.11 These estimates do not include any downstream benefits for wetlands. Scenario 1 is estimated to result in 2,390 ha of constructed wetlands, a 15% increase from the existing 15,500 ha.[20] Several New Zealand studies have placed values on wetlands, based on local willingness to pay surveys[21] or transferring values from international studies.[22] Recent analysis by Marsh (2015) suggests that the value of improvements to the Whangamarino wetland could be significant, and in the order of $15 million per annum.[23]

5.12 It is not possible to make a direct comparison between the 30% reduction in N and P analysed here and proportion achievement of Scenario 1 as used for cost analysis. However, the analysis does show that monetary benefits estimated from a limited component of total benefit, are in the same order of magnitude as the estimated costs for the 10% or 25% shift towards Scenario 1 assuming constrained land use change (Table 1). And costs would be expected to be even lower if unconstrained land use was assumed, as discussed above. This suggests that the relationship between benefits and costs should be examined further, and the current analysis should not be relied upon to prefer a 10% shift toward Scenario 1 as distinct from other (more ambitious) steps toward Scenario 1.

[20] Wedderburn L and Coffin A (2016) Integrated Assessment One: Assessment of Scenarios from modelling round one. Report No. HR/TLG/2015-2016/6.2
[21] Kirkland WT (1988) Preserving the Whangamarino wetland – an application of the contingent valuation method. MAgSc Thesis, Massey University.
[22] Patterson MG and Cole AO (2013) Total economic value of New Zealand's land-based ecosystems and their services. In: Dymond JR (ed) *Ecosystem services in New Zealand: conditions and trends*. Landcare Research New Zealand Ltd.
– conditions and trends. Manaaki Whenua Press, Lincoln, New Zealand.
[23] Marsh D (2015) Statement of Evidence in Chief of Dr Dan Marsh for the Director General of Conservation. In the matter of A review of conditions of Resource Consent 101727 held by Waikato Regional Council.

6 SELECTION CRITERIA

6.1 The Collaborative Stakeholder Group (CSG) adopted a set of criteria for policy selection.[24] These include "*Realistic to implement, monitor and enforce*" and "*Optimises environmental, social and economic outcomes*", which is elaborated as: "*Does the policy:*

- *aim for cost-effective solutions?*
- *provide confidence and clarity for current and future investment?*
- *provide realistic timeframes for change?*"

6.2 Whether the proposed policy is *realistic* features in both these criteria. This appears to have been used to limit improvements to 10% achievement of Scenario 1 as a ten-year target, with more significant improvements pushed out to a staged achievement of an 80-year target.

6.3 This slow rate of improvement partly reflected the CSG's understanding of a lag effect; water quality outcomes are only achieved after some delay because of the of the latency of soil and groundwater transport processes, meaning there will be a delay to achieving a new equilibrium water quality following land use change. However, what is realistic is also seen to reflect costs. The Section 42A Report notes that the technical information suggests a 10% reduction in emissions in 10 years is a difficult but achievable goal, and that a different level of reduction would need to be justified by new information demonstrating the achievability of that proposed level.[25]

6.4 But, as explained in the body of my evidence, the scenario modelling examined the costs of land use and other changes which might be used to reduce discharges to water. Changing land use from, say, dairy farming to forestry takes time, but it is not using new technologies. Ten years is an adequate time for significant change.

6.5 Kerr and Olssen (2012) examined the speed of land use change following significant changes in commodity prices. They suggested for land use change consistent with new relative prices, 50% of expected shift

[24] Collaborative Stakeholder Group (2015) The Collaborative Stakeholder Group's policy selection criteria.
[25] At [394].

occurred after six years and 75% after 12 years.[26] Land use change does not occur immediately, but much more significant changes are possible than would be implied by limiting the ten-year outcome to a 10% achievement of Scenario 1.

6.6 As I noted above, the short-run costs of land use change are already included in the results through using modelling techniques, which are likely to be higher than longer-run cost which allow for innovation and/or options not imagined by the researchers. Imposing an additional "realistic" criterion on top of this is over-weighting these (higher) short-run costs.

6.7 Under the "*Optimises environmental, social and economic outcomes*" criterion, *realism* as a sub-criterion is used to define optimal levels of intervention. However, the optimal outcome should be defined as when the greatest wellbeing for the Region is produced from the use of the resources of the Waikato and Waipā river catchments. This takes account of the extent to which the benefits of additional improvements in water quality offset the costs of achieving them.

6.8 One of the sub-criteria is *aiming for cost-effective solutions* (lowest cost to achieve a certain goal). It provides no basis for identifying what that goal should be, ie what is the optimal level of water quality. Cost-effectiveness as a criterion might be used to isolate interventions for which the costs per unit improvement in water quality are lowest, but it does not enable identification of all improvements for which the benefits exceed the costs.

6.9 The acceptability of higher costs needs to be based on some estimate of what benefit is achieved as a result. Undertaking cost benefit analysis (CBA), or using a CBA framework, would better address the question of whether costs are acceptable, and if a specific policy "*Optimises environmental, social and economic outcomes*." Without a CBA, I fail to see that this criterion can be robustly applied.

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[26] Kerr S and Olssen A (2012) Gradual Land-use Change in New Zealand: Results from a Dynamic Econometric Model. Motu Working Paper 12-06. Motu Economic and Public Policy Research.

7 CONCLUSIONS

7.1 From the available data, costs can be summed using the impacts on farm-level profits, as provided by Doole *et al*. (2015b). These costs show a smooth upward sloping cost curve, with no obvious point at which effort should be curtailed in the short or long-run. The costs are for steps taken to limit emissions, using existing technology (including constrained land use change), a significant percentage of which could be undertaken within ten years.

7.2 The analysis has not included costs of unconstrained land use change for achieving 10% and 25% shifts towards Scenario 1. This appears to be a significant omission which could have identified lower costs.

7.3 An examination of benefit values which might apply suggest that, using partial analysis only (ie. only some of the benefits), they are of the same order of magnitude as costs to achieve higher percentage shifts than 10% towards Scenario 1 based on constrained land use change.

7.4 A review of selection criteria suggests “feasibility” or “realistic” has been used to limit what ten-year targets have been considered. In the light of other analysis, this appears to be unjustified. The cost analysis already takes account of feasible land use changes.