BEFORE INDEPENDENT HEARING COMMISIONERS

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	Proposed Waikato Regional Plan Change 1: Waikato and Waipa River Catchment

STATEMENT OF PRIMARY EVIDENCE OF GRAEME JOHN DOOLE

FOR DAIRYNZ LIMITED

SUBMITTER 74050

3 May 2019

DairyNZ
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1. Qualifications and experience

1.1 My full name is **Dr Graeme John DOOLE**. I am currently the Principal Economist and Leader of the Economics Team at DairyNZ. I recently joined this organisation, following four years acting as an Economic Advisor to the New Zealand Government. My advisory work centred on the economic impacts of policies related to the improved management of water resources.

1.2 During the time that I worked with the New Zealand Government, I was also a Professor of Environmental Economics at the University of Waikato. I held various positions at the University of Western Australia (Perth, Australia) prior to these appointments, where I worked for fourteen years.

1.3 The focus of my research is the economic assessment of policies and practices to reduce the environmental impacts of agriculture. This has principally involved the development and application of mathematical models of catchments, farm systems, contaminant loss, and populations. A lot of this work has focused on profitable ways to reduce the environmental footprint of New Zealand dairy production.

1.4 I have published over 60 refereed journal articles and have supervised post-graduate students for a decade. Nearly half of these peer-reviewed articles are focused on New Zealand environmental management, particularly in the context of the economic evaluation of sustainable dairy production.

1.5 While at the University of Waikato, a core part of my work program involved contributions to the Healthy Rivers Wai Ora (HRWO) project, which coordinated the development of Plan Change 1 (PC1) prior to notification. My contribution encompassed multiple roles:

a. I was a member of the Technical Leaders Group from 2014 to 2018. In this role, I helped to provide input with regards to communicating information, discipline-specific matters, project design and management, and research prioritisation.

b. I developed and applied the HRWO economic model (Doole, 2016b, c; Doole et al., 2016c). This model incorporated detailed hydrological models concerning *E. coli* (Semadeni-Davies et al., 2015a), sediment (Yalden and Elliott, 2015), nitrogen (Semadeni-Davies et al., 2015b), and phosphorus (Semadeni-Davies et al., 2015b).

c. I wrote ten reports describing the development of the HRWO economic model and its application to inform decisions made for the Waikato River catchment within PC1. These reports are: Doole (2016a, b, c, 2018), Doole et al. (2015a, b, 2016a, b, c), and McDonald and Doole (2016).

1.6 I have read the Environment Court's Code of Conduct for Expert Witnesses contained in the Environment Court's Practice Note 2014, and I agree to comply with it. In that regard, I confirm that this evidence is within my area of expertise except where I state that I am relying on the evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

2. Executive summary

2.1 My evidence pertains to the *importance of careful, graduated transition from the current state towards a state where improved water-quality outcomes are observed throughout the Waikato River catchment*. Hence, I support the key principles contained within the proposed PC1 regarding reducing the environmental footprint of the dairy sector located in this catchment. In particular, I agree with the overarching goal for PC1 to take the first step on an 80-year journey, as espoused in paragraph 554 of WRC (2019).

2.2 In my professional opinion, there are several clear reasons why requiring the dairy sector within the Waikato River catchment to mitigate more than is currently proposed within PC1 is unjustified. The main reasons are:

a) The dairy sector is already expected to bear most of the economic impact of proposed PC1. This does not align with the contaminant load associated with this sector. Indeed, the sheep and beef sector is responsible for generating more *E. coli*, phosphorus, and sediment in the Waikato River catchment, relative to the dairy sector.

b) Higher levels of abatement are expected to incur a substantially greater cost on the dairy sector.

c) The distribution of economic impacts within the dairy sector is broader than that estimated within modelling assessments. This means that the impacts of policy will be disproportionately felt across the dairy sector.

d) Higher levels of abatement will place greater financial risk on farmers who have invested in assets prior to the notification of PC1.

e) The dairy sector is a key part of the Waikato and New Zealand economy. Therefore, requiring greater reductions in contaminant loss in this sector will have major economic implications at these levels, both in the dairy sector and in related industries.

f) There is substantial uncertainty related to the uptake of mitigation practices and their associated cost. A staged approach provides for adaptation and learning, without placing undue financial risk on farmers.

g) It is important to follow a gradual, staged approach in the early years of introducing a regulation. This helps provide time to establish an effective implementation framework; build skills and motivation; and allow careful targeting of research, development, and extension.

2.3 Each of these points is presented in more depth below, in a series of subsections. However, before presenting these, the next section describes the modelling method used to generate a number of important economic results detailed below.

3. Methodology used to estimate impacts of policy on the dairy sector

3.1 Throughout my evidence, I draw on modelling work that assessed the economic impacts associated with water-quality improvement in the Waikato River catchment. These outputs are taken from the Input-Output (IO) model applied by Market Economics during the HRWO process (McDonald, 2015; McDonald and Doole, 2016). I concentrate on the output of the IO model in this section because it captures several key effects of alternative policy scenarios on the dairy sector, as well as capturing flow-on impacts. The model is static and takes the output from the catchment level model (Doole, 2016a) as input. It uses these data, alongside other information, to assess the Freshwater Management Unit (FMU), regional, and national effects of the different policy scenarios.

3.2 IO models are the most widely-applied method for estimating the regional impacts of environmental policy, both in New Zealand and overseas. Additionally, they are one of the most popular economic methods applied globally (Miller and Blair, 2009), based on their clarity and descriptive capacity. IO models study the flow of products, inputs, and sales between households and industries. They provide a means to estimate the regional impacts of a given policy mechanism, based on the idea that an initial change in net revenue entering into a regional economy—for example, in response to a change in milk production arising from reduced dairy production intensity—will affect subsequent spending in other industries within this economy, but the effect of these diminished contributions will dissipate over time due to the leakage of funds from the local economy (e.g. through expenditure outside of the region or through saving) (Mills, 1993). Further information on the modelling method is available in Doole et al. (2015a, b; 2016c), McDonald (2015), and McDonald and Doole (2016).

3.3 The choice of an IO model to estimate FMU-, regional-, and national-level impacts was based on several benefits associated with this method.

a) The IO approach readily produces results that are disaggregated by study regions—in this case, the different FMUs, Waikato region, and New Zealand—and economic sectors. With regards to the latter, 107 economic sectors are incorporated in the model.

b) The adoption of an IO model allowed its straightforward integration with the farm- and catchment-level models, such that the farm-, catchment-, FMU-, regional-, and national-level implications of alternative limits could be ascertained in an integrated way.

c) The use of an IO model was partially justified by the existence of the Waikato Region Multi-Regional IO Table, which was initially developed for the Waikato Regional Council Economic Futures Model (McDonald, 2010). The extension of a previous framework is more cost-effective than developing a framework from nothing, especially given that the existing framework has been applied previously and extension can consider practices and principles that were learnt during its prior employment.

d) The IO format was consistent with the budget and timeframe available for the project.

e) It was developed with the Collaborative Stakeholder Group—some of who provided key information during model development—before the notification of PC1.

f) The IO model assesses the impacts of policies targeted at multiple contaminants, and not just nitrogen.

g) A lack of information pertaining to inter-regional investment flows made it difficult to justify the application of a multi-regional Computable General Equilibrium model, a potential alternative to an IO framework.

h) A Computable General Equilibrium model has an advantage in that it accounts for price changes in markets, following the impacts of policy on supply and demand. While the employed method was based on the IO format, a concerted effort was made to take full consideration of the 'circular flow of income' within an economy.

3.4 Further justification and discussion of alternative approaches is provided in Doole et al. (2015a, b; 2016c), McDonald (2015), and McDonald and Doole (2016).

3.5 I did not apply the IO model myself during the HRWO process, nor am I an expert in the application of these models. Nevertheless, I am confident that the development and use of this model are consistent with good practice in the field of regional economic modelling and the economic assessment of environment policy, more generally.

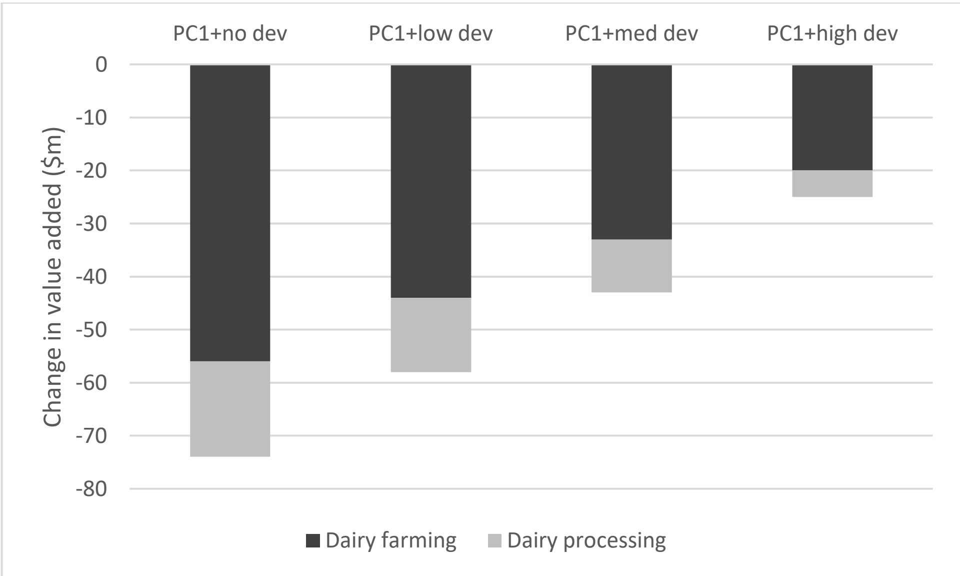
4. The dairy sector will bear most of the cost of PC1

4.1 The report of McDonald and Doole (2016) evaluated the impact of the proposed PC1 at the FMU, regional, and national scale. Therein, regional economic impacts were computed for four scenarios: the policy mix with no, low, medium, and high development of iwi land. These were compared with the predicted outcomes associated with the business-as-usual assessment reported in Doole (2016a).

4.2 Figures 1 and 2 are generated based on the information presented within McDonald and Doole (2016). Figure 1 presents the change in value added. This is a standard indicator of economic activity, similar to regional GDP but excluding production taxes. (Indeed, value added and regional GDP are seldom different by more than 1%.) In comparison, Figure 2 presents employment impacts, measured in terms of Modified Employment Counts or MECs. Statistics New Zealand use the Employee Count (EC) measure. This counts salary and wage earners for a reference period, but excludes those who pay themselves a wage. The MEC measure is based on ECs, but includes an adjustment to incorporate an estimate of the number of working proprietors.

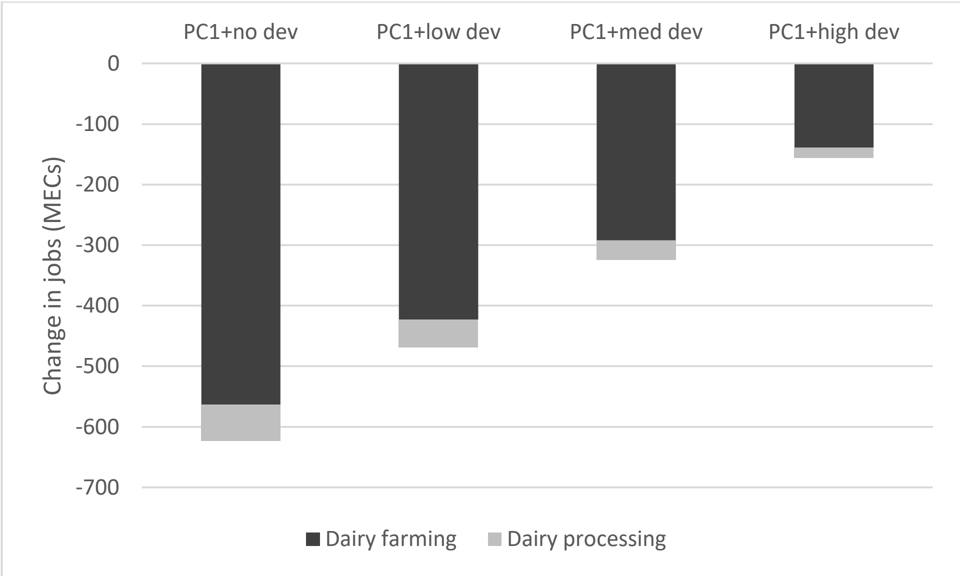
4.3 Figure 1 highlights that the total reduction in value added within the dairy sector is around $74 million, $58 million, $43 million, and $25 million for the policy mix with no, low, medium, and high iwi-land development cases, respectively. These are around 3.7, 3.2, 2.7, and 1.7 times greater than those costs estimated for the sheep and beef sector. Moreover, these costs are around half of the total decrease in value added occurring as a result of the proposed policy mix. In each case, the dairy sector is affected more than any other sector of the regional economy.

4.4 **Figure 1.** Impacts of the proposed policy mix on value added ($ million (m)) for the dairy sector in the Waikato Region, relative to the predicted business as usual, with constrained land-use change. The modelled scenarios represent the policy mix with no (PC1+no dev), low (PC1+low dev), medium (PC1+med dev), and high (PC1+high dev) development of iwi land. Source: McDonald and Doole (2016).



4.5 Additionally, Figure 2 highlights that the policy mix with no, low, medium, and high iwi-land development will lead to a decrease of around 623, 469, 324, and 156 jobs, respectively, in the dairy sector in the Waikato region, relative to the business as usual scenario. These are around 4.6, 4.9, 4.9, and 4 times larger than those estimated for the sheep and beef sector.

4.6 **Figure 2.** Impacts of the proposed policy mix on employment (Modified Employee Counts) for the dairy sector in the Waikato Region, relative to the predicted business as usual, with constrained land-use change. The modelled scenarios represent the policy mix with no (PC1+no dev), low (PC1+low dev), medium (PC1+med dev), and high (PC1+high dev) development of iwi land. Source: McDonald and Doole (2016).



4.7 These impacts are likely a very-conservative estimate of what can be expected to occur in reality. In the primary modelling assessments used to assess the economic impacts of the policy, the cost and efficacy of mitigations are fixed at their averages (Doole, 2016b). Further, the uptake of these practices and their capacity to start abating contaminant loss is assumed to be instantaneous. These assumptions align with standard practice in the economic assessment of environmental policy, particularly in New Zealand (Hanley et al., 2007; Tietenberg and Lewis, 2009; Doole et al., 2019). Yet, they provide an overly-optimistic view of abatement cost. In practice, the transition of a catchment to one that conforms with a policy is not instantaneous. Rather, it is plagued with inefficiency as farmers learn how to meet the needs of legislation in the presence of market variation and uncertainty around achieving cost-effective abatement on their farm. Additionally, the response of the environment to the uptake of these measures across time is difficult to forecast, especially given that mitigation uptake is slow and uneven across a catchment (Doole et al., 2019).

4.8 Overall, Figures 1 and 2 show that the dairy sector in the Waikato River catchment will face significant, yet tolerable, costs with the staged implementation of PC1. This sector bears most of the cost associated with water-quality improvement. Around half of the total decrease in value added occurring as a result of the proposed PC1 will accrue to the dairy sector, despite making up only a third of the catchment on an area basis and other sectors also contributing to water-quality decline therein.

4.9 The dairy sector bears most of the abatement cost associated with improved water quality. Yet, it is only one of a number of land-based activities that are driving water-quality outcomes. Thus, it is potentially having to shoulder a disproportionate amount of the cost of mitigating contaminant loss across the catchment. Doole et al. (2015a, b) portray the current state of the catchment. In this current state, the dairy sector is responsible for twice the nitrogen loss attributed to the sheep and beef sector (Table 1). However, the dairy sector has an *E. coli*, phosphorus, and sediment load that is 73%, 93%, and 42% of the sheep and beef sector (Table 1). This outcome aligns with scientific research pertaining to the primary sources of each of these contaminants on a per-hectare basis (see, for example, McDowell and Wilcock, 2008). For *E. coli*, the result for sheep and beef farms in this catchment may reflect the combined effects of greater areas of this land use being present, relative to dairying; lower amounts of stream fencing; and greater runoff to waterways, given the steep slopes on which this type of agriculture can take place (Semadeni-Davies et al., 2015a).

4.10 The focus on four contaminants within PC1 (Waikato Regional Council, 2014, 2019) highlights the need to consider the impact of all sectors on water quality. The dairy sector must improve its environmental footprint. Yet, it is not the major source of most of the contaminants entering the Waikato River and is already expected to bear most of the mitigation cost estimated to accrue to the implementation of PC1. In my opinion, given this context, it is difficult to justify asking this sector to bear more of the economic burden of environmental improvement.

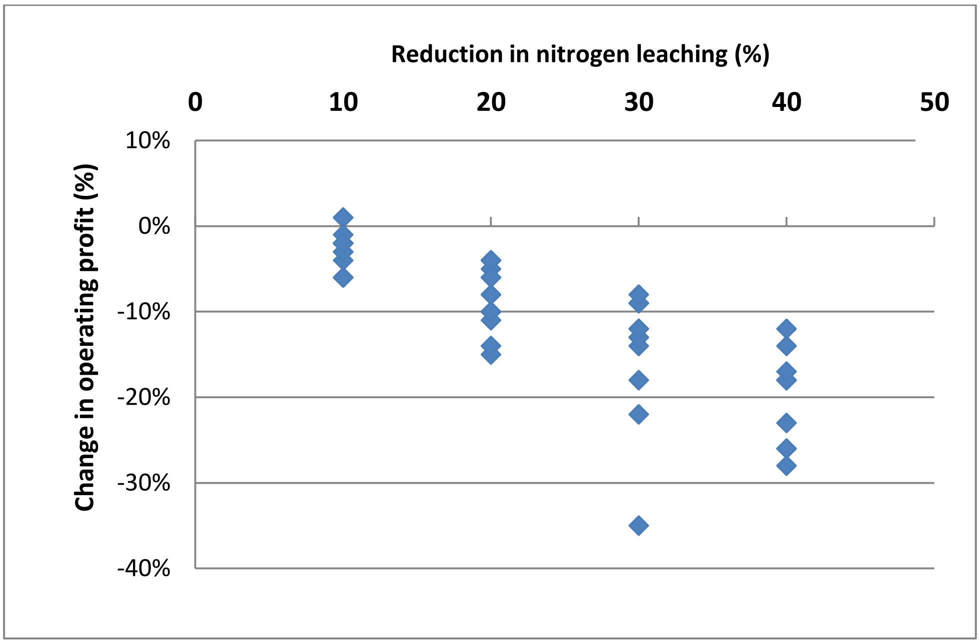
4.11 **Table 1.** Percentage of contaminant loss accruing to the dairy and sheep and beef sectors in the Waikato River catchment, in the current state reported in the economic assessments reported by Doole et al. (2015a, b).

Contaminant	**Dairy load, as a percentage of sheep and beef**	**Dairy load, as a percentage of total load**	**Sheep and beef load, as a percentage of total load**
E. coli	73	41	56
Phosphorus	93	33	36
Sediment	42	29	71
Nitrogen	200	56	28

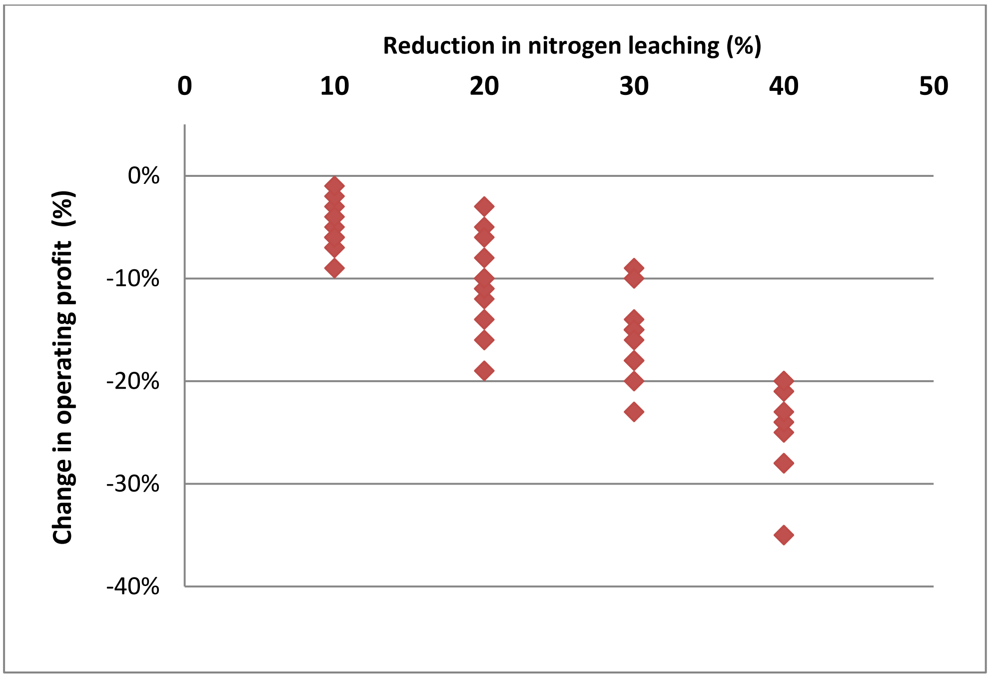
5. More abatement would incur significant additional costs on the dairy sector

5.1 The main costs associated with environmental policy are those that accrue to transition. Economic theory posits that profit will decline as more abatement is performed (Hanley et al., 2007; Tietenberg and Lewis, 2009). This is clearly observable in abatement-cost relationships estimated for representative dairy farms across the catchment (Figures 3 and 4) (DairyNZ Economics Group, 2014). Figures 3 and 4 show that operating profit is predicted to fall dramatically as the amount of nitrogen abatement increases above 10%, both in the Waipa-Franklin and Upper Waikato areas. This is in line with earlier findings. For example, Doole (2012) found that abatement cost on more than 400 Waikato dairy farms started to increase dramatically, once a level of reduction greater than 10% was simulated.

5.2 **Figure 3.** The relationship between operating profit and nitrogen leaching on dairy farms in the Waipa-Franklin area. Source: DairyNZ Economics Group (2014).



5.3 **Figure 4.** The relationship between operating profit and nitrogen leaching on dairy farms in the Upper Waikato area. Source: DairyNZ Economics Group (2014).



5.4 Maintaining the current staging proposed in PC1 reduces the costs accruing to transition in the near term. This is particularly important given the value of the dairy sector for generating regional income (see Section 8 below).

5.5 The cost to the dairy sector of achieving greater levels of contaminant reduction than proposed in PC1 is also evident in economic evaluations that were carried out during the HRWO process. These early assessments centred around the assessment of four aspirational water-quality scenarios, under the direction of the Collaborative Stakeholder Group prior to the notification of PC1. (These scenarios are described in detail on pages 5-6 of Doole et al. (2015a).) The four scenarios can be summarised as follows:

a. Scenario 1 (S1): Substantial improvement in water quality for swimming, taking food, and healthy biodiversity. This involves an improvement in water quality everywhere, even if it is already meeting the minimum acceptable state.

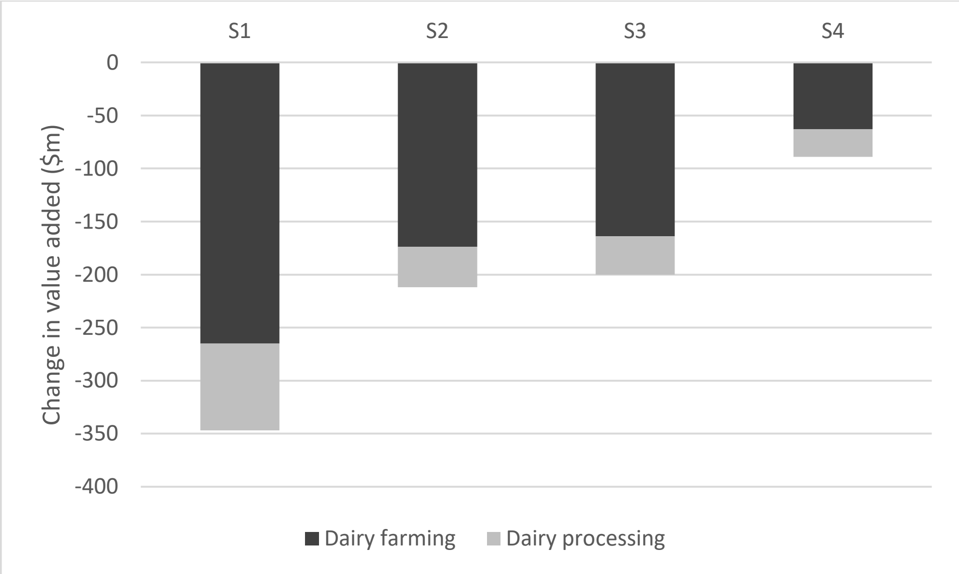
b. Scenario 2 (S2): No further degradation in water quality, and improvements to at least minimum acceptable state.

c. Scenario 3 (S3): Some general improvement in water quality for swimming, taking food, and healthy biodiversity, even though this may not reach the minimum acceptable state everywhere.

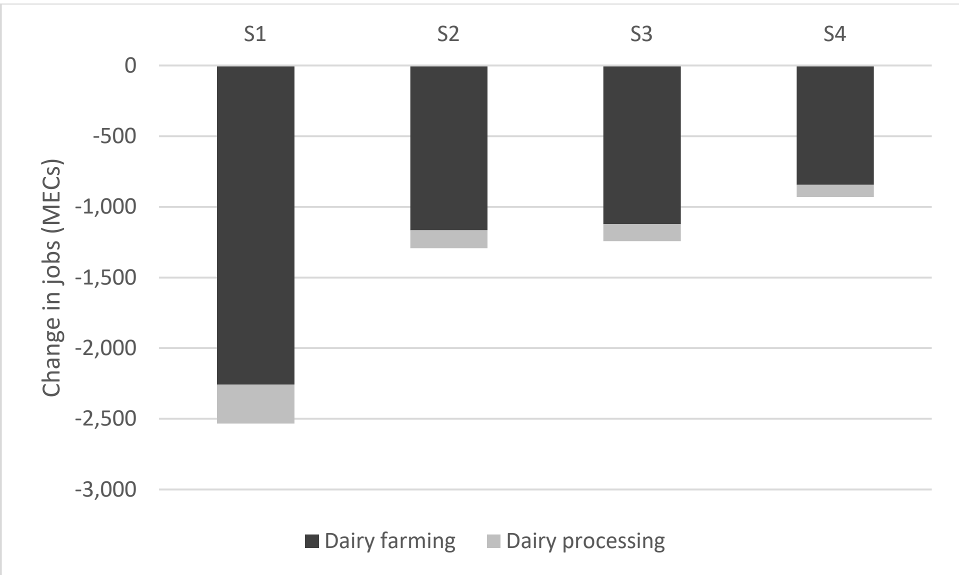
d. Scenario 4 (S4): No further degradation in current water quality, despite projected extra contaminant loads (i.e. the nitrogen load-to-come) emerging from groundwater.

5.6 The report of Doole et al. (2015a) described an evaluation of how land and land-use management would have to change to achieve the water-quality outcomes defined within each of these scenarios. Gary McDonald of Market Economics computed the regional economic impacts associated with each of the scenarios listed in paragraph 5.5. These impacts are described in Section 4 of Doole et al. (2015a). Figures 5 and 6 below are generated based on the information presented therein. In general, water-quality goals become less stringent as we move from Scenario 1 to Scenario 4.

5.7 **Figure 5.** Impacts on value added ($ million (m)) for the dairy sector in the Waikato Region, relative to current state, with constrained land-use change. Scenarios 1–4 are summarised in paragraph 5.5 above, with a detailed description provided in Table 1 of Doole et al. (2015a). Source: Doole et al. (2015a).



5.8 **Figure 6.** Impacts on employment (Modified Employment Counts) for the dairy sector in the Waikato Region, relative to current state, with constrained land-use change. Scenarios 1–4 are summarised in paragraph 5.5 above, with a detailed description provided in Table 1 of Doole et al. (2015a). Source: Doole et al. (2015a).



5.9 Figure 5 shows that the total decrease in value added within the dairy sector is around $347 million, $212 million, $202 million, and $89 million for Scenarios 1, 2, 3, and 4, respectively. These represent 56%, 68%, 64%, and 92% of the overall decline in value added estimated for each of these scenarios. The costs experienced in the dairy sector are 2.5, 2.2, and 1.3 times those imposed on the sheep and beef sector in Scenarios 1, 2, and 3, respectively. In Scenario 4, no cost is borne by the sheep and beef sector, but the dairy sector experiences a cost of around $89 million. These results highlight the significant impact that water-quality improvement would potentially have on the dairy sector. This is particularly observable in Scenario 4, which is targeted towards managing the nitrogen load-to-come emerging from groundwater, chiefly in the Upper Waikato FMU.

5.10 Additionally, Figure 6 highlights that Scenarios 1, 2, 3, and 4 will lead to a loss of around 2,533; 1,292; 1,243; and 931 jobs, respectively, in the dairy sector in the Waikato region. The job losses experienced in the dairy sector are around 3.5, 23, and 18 times those observed in the sheep and beef sector in Scenarios 1, 2, and 3, respectively. In Scenario 4, 75 jobs are created in the sheep and beef sector due to the expansion of this land use, relative to the current state. In contrast, around 931 jobs are lost in the dairy sector in Scenario 4. These forecast outcomes emphasise the disproportionate effect of the proposed PC1 on the dairy sector in the Waikato region.

5.11 Overall, two key points are evident. First, the extent of economic impact accruing to the dairy sector increases with the simulated stringency of water-quality limits. Second, the dairy sector bears most of the economic impact accruing to the improvement of water quality within the Waikato River catchment. Figures 3 and 4 show the high cost associated with achieving larger reductions in nitrogen on Waikato dairy farms. Figures 1, 2, 5, and 6 extend these to show the high cost, in terms of both value added and jobs, borne by the dairy sector when reductions in all contaminants are considered.

5.12 The economic models applied throughout the HRWO process did not incorporate any special emphasis on nitrogen. PC1 is focused on all four contaminants (Waikato Regional Council, 2019), in line with the need to give effect to the *Vision and Strategy for the Waikato River* (Waikato Regional

Council, 2014). Early assessments of the cost associated with achieving different levels of water-quality improvement performed for the Collaborative Stakeholder Group contained a broad focus on all four contaminants (Doole et al., 2015a, b). However, the policy-mix assessment (Doole et al., 2016a) provided a sharper focus on nitrogen, particularly through rules around intensification and the 75th percentile restriction for dairy farming. This greater focus on N appeared to have come from discussions among the Collaborative Stakeholder Group.

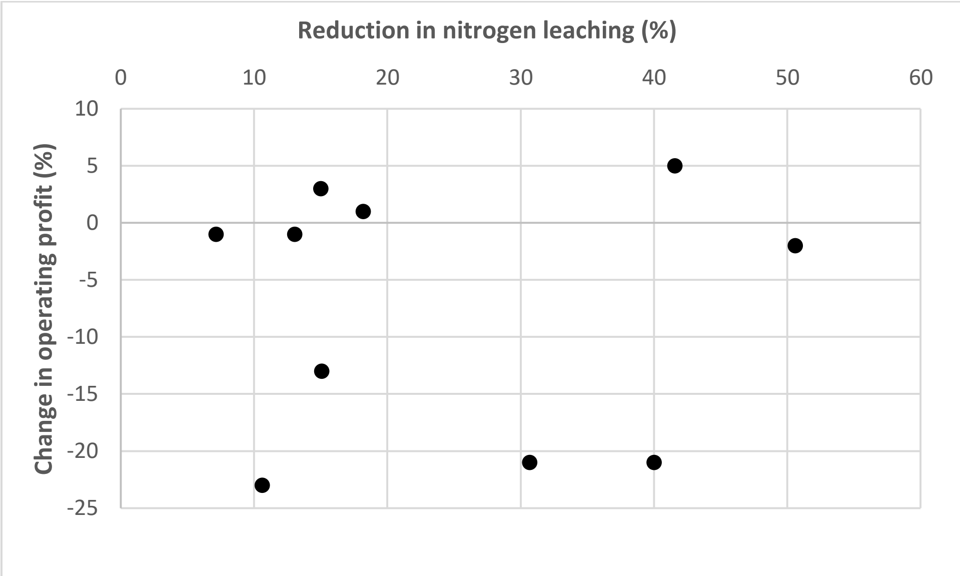
6. The distribution of abatement costs is much broader than that estimated by modelling

6.1 Figures 1–6 represent estimated costs for dairy farms associated with various water-quality improvement scenarios, based on data for average farms. Each 'average' farm is deemed to be representative of a certain type of dairy farm present across a significant area of the catchment (DairyNZ Economics Group, 2014). This approach is consistent with standard modelling practice (Doole, 2015; Doole et al., 2016c). Yet, the consideration of average effects serves to dampen the impacts that affect some members of the population in disproportionate ways.

6.2 Ledgard et al. (2017) analysed the relationship between nutrient losses and farm financial performance on twelve dairy farms in the Waikato River catchment. These farms were selected based on their representativeness and because they leached more nitrogen than the 75th percentile limit within their respective FMU. FARMAX and OVERSEER modelling was used to establish the relationship between the abatement of nitrogen and operating profit for each farm (DairyNZ Economics Group, 2014; Ledgard et al., 2017). Mitigation practices were added consecutively for each farm, until the 75th percentile was reached. While these farms were deemed representative, the impacts of mitigation on their financial performance are indicative of the distribution of economic impacts that could be associated with reducing nitrogen loss on Waikato dairy farms more generally, especially on high-leaching units.

6.3 Figure 7 presents the relationship between operating profit and the reduction in nitrogen leaching achieved for ten farms, taken from Ledgard et al. (2017). (Two farms were excluded from this study after OVERSEER files were modified to correctly represent the farm system.) The variation present between these real farms means that it is difficult to discern a direct relationship between abatement and financial performance. Indeed, statistical analysis indicates no correlation at all, given this diversity.

6.4 **Figure 7.** Operating profit and nitrogen leaching for ten dairy farms in the Waikato River catchment. Source: Ledgard et al. (2017).



6.5 According to economic theory, on average within a population, profit falls at a faster rate as the amount of mitigation performed increases (Hanley et al., 2007; Tietenberg and Lewis, 2009; Doole, 2012). Figure 7 extends this argument to demonstrate that while this relationship holds on average, there is substantial diversity present between individual farms. Indeed, some farms can experience large financial losses at low levels of mitigation, while others can experience low financial losses at high levels of mitigation.

6.6 PC1 provides the first step on an implementation journey, by aiming for 10% progress towards 80-year water-quality targets. However, though the proposed policy is meant to be intermediary and align with a gradual approach to achieving water-quality improvement, it is important to note that its impact will be felt unevenly across the farming population. Regulation may drive efficiency gains across some members of the population (Figure 7), even at substantial levels of mitigation. However, on the other hand, it could also reduce profits enormously for some farm businesses, even if only small reductions in nitrogen loss are required (Figure 7). This could affect farm solvency, a topic that is explored further in the next section.

6.7 This discussion highlights that economic assessments of mitigation cost based on average-farm data provide valuable insight, yet they do not provide the full picture with respect to the distributional impacts of policy. The distribution of abatement cost is particularly impactful for those farmers who face substantial risk because of their higher cost of abatement. The downside risk facing these producers emphasises the importance of a careful, graduated transition from the current state towards a state where improved water-quality outcomes are observed.

7. Requiring more abatement will place increased financial risk on farmers

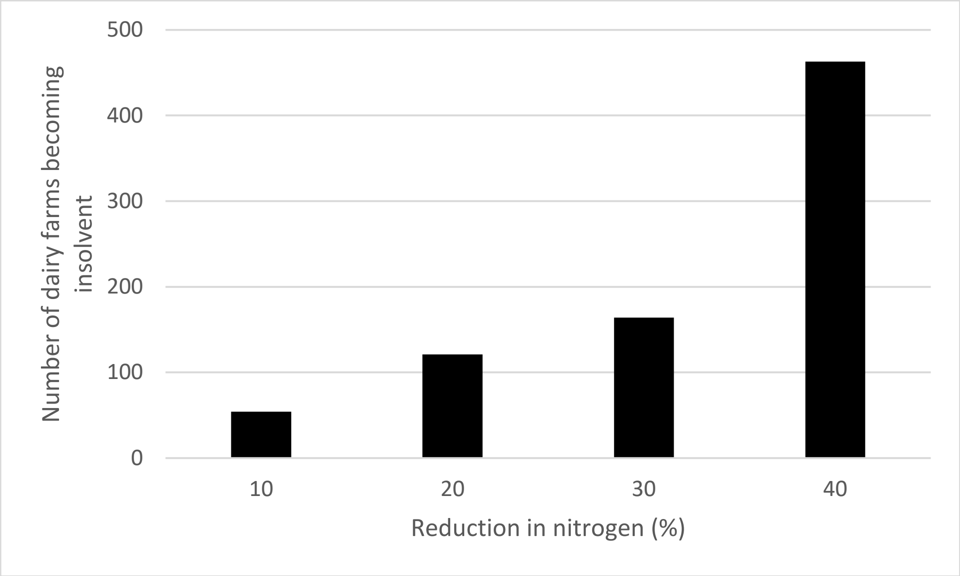
7.1 Agricultural land is always expensive, relative to the annual return it can generate, because it seldom depreciates and therefore typically has a high resale value. Accordingly, agricultural sectors are characterised by carrying high levels of debt and having to service this debt across subsequent years. For example, dairy farms in the Waikato River catchment carry around $6b of debt, with most of this investment predicated on a capacity of this land to produce enduring returns in the absence of limits placed on contaminant loss. These investment decisions were made in many cases before or without a full understanding of the form and implication of environmental limits contained within the proposed PC1. The staged approach present in PC1 helps to ensure that these investors continue to be able to service loans.

7.2 The impact of increased abatement costs on the capacity of dairy farms in the catchment to service debt was explored. Operating profit per hectare and total debt per hectare were collected for a sample of dairy farmers in the Waikato region over five milking seasons (2012-13 to 2016-17). The total amount of farms in the sample was 1,040. Debt payments to be serviced annually were then determined, using assumptions that an average loan period was for 25 years and an average interest rate was 6%. The impact on operating profit pertaining to diverse reductions in nitrogen leaching was then computed through determining the weighted average percentage loss in operating profit across 26 representative farms (DairyNZ Economics Group, 2014). These data allowed the calculation of how falls in operating profit linked to reductions in nitrogen leaching reduced the capacity of different farms to service their annual debt payments.

7.3 Statistical analysis indicated that a 10%, 20%, 30%, and 40% decrease in nitrogen across dairy farms in the catchment is estimated to lead to around 54, 121, 164, and 463 farms being unable to service their annual debt payments and therefore undergo foreclosure (Figure 8). These numbers correspond to around 2%, 4%, 6%, and 17% of dairy farms in the Waikato River catchment. This represents a significant social impact, particularly as this burden will be borne by many younger farmers. Moreover, it is likely a very-conservative estimate of the number of farms expected to exit the industry because those costs associated with reducing the other contaminants (i.e. phosphorus, sediment, and microbes) has not been considered. The importance of a staged transition involving a careful, graduated reduction in contaminant loss is consequently reinforced.

7.4 Nevertheless, the exit of these farmers would likely allow their replacement with business operators who are more efficient from an economic and/or environmental perspective. This may serve to dampen the negative effects of farm insolvency at the catchment level.

7.5 **Figure 8.** Impacts on reductions in nitrogen on the number of dairy farms becoming insolvent in the Waikato River catchment.



7.6 Some abatement technologies are durable and therefore provide a stable source of mitigation, particularly when they do not depreciate quickly and/or cannot be readily dis-adopted. Examples are stream fencing, wetlands, the planting of hillsides with poplar trees, and the use of stand-off pads. This contrasts with activities that are less stable in light of climate and market variation—such as reductions in stocking rate or fertiliser application. To a regulator, durable forms of mitigation typically provide greater security over the duration and effectiveness of abatement. However, they generally require greater investment from farmers, in terms of upfront cost. The gradual, staged approach incorporated in PC1 helps to increase the amount of funds available to farmers to use to invest in these more effective and stable forms of mitigation. The latter point is particularly relevant given the high level of debt present in the dairy sector, discussed above.

8. The dairy sector is a key part of the national and regional economy

8.1 The dairy sector is a significant part of the New Zealand economy. It provides around a quarter of the value of all national merchandise exports, generating annual export revenue of around $17 billion (MPI, 2018). Further, it employed around 38,700 people in 2017, with around 70% of these jobs being on farms and the remainder in the processing sector (NZIER, 2018).

8.2 The dairy sector provided around $2.5b in wages in 2017, with around 80% of these being provided in rural areas (NZIER, 2018). These benefits flow onto other sectors of the economy. Dairy farmers are the largest purchasers of agricultural support services, basic wholesale materials, and veterinary services in New Zealand. Further, dairy-processing companies are the largest consumers of polymer and rubber products, as well as rail transport. The broad distribution of the benefits of dairy production are highly favourable for regional development, particularly in areas where other sources of revenue and jobs can be limited.

8.3 Dairy farming is a particularly important part of the Waikato economy. The Waikato is the nation's largest dairy-producing region, containing around a quarter of the nation's herds and producing around 27% of the national milk supply. It occupies approximately a third of the land area in the Waikato River catchment, with approximately 2,800 herds on 370,000 effective milking platform hectares.

8.4 The dairy sector was the chief industry in the Waikato region in 2017, in terms of income generation. It directly contributed 11% of Waikato's regional value added in 2017, more than three times higher than the percentage contribution of dairy to the national economy.

8.5 The dairy sector generated around $2,200 million of regional value added in the Waikato in 2017. The on-farm sector contributed around $1,600 million, while dairy processing contributed around a further $600 million (NZIER, 2018).

8.6 The dairy sector employed 13,400 workers in the Waikato region in 2017-18, which accounted for 6.7% of total regional employment. The on-farm sector accounted for 9,900 of these jobs, with dairy processing providing a further 3,500 jobs. Employment growth in the dairy processing sector (+3.1% per year) has exceeded total employment growth (+1.5% per year) for the Waikato region over the last decade.

8.7 The importance of the dairy sector to the Waikato region emphasises the need for gradual transition. It emphasises the potential for rapid transition to impose far-reaching negative economic consequences, both on the dairy sector and the broader regional economy (Doole et al., 2015a, b).

9. High uncertainty with regards to the link between water quality and dairy financial performance

9.1 The principal determinant of water-quality improvement in rural areas is the degree to which practices that reduce contaminant load are taken up by farmers. This is an inherently temporal process (Pannell et al., 2006), but there remains a pertinent lack of data relating to the maximum extent and speed with which mitigation practices can effectively diffuse through a population (Doole et al., 2019), particularly one characterised by significant variation in management skill and farm resources. This is further hampered by an apparent scarcity of skilled individuals to undertake farm environment planning—a key component of the proposed PC1—alongside farmers. These key sources of risk emphasise the need for the staged approach proposed within PC1, as farmers are therein provided the opportunity to learn how best to farm under environmental limits, while the financial risk to their business is reduced.

9.2 Costs associated with water-quality improvement in the Waikato River catchment are displayed for several scenarios in Sections 4–6. Yet, these costs are only indicative because the magnitude of transition costs is difficult to estimate through economic modelling. The reasons for this include, but are not limited to: (a) a lack of information pertaining to how input data changes across time, (b) little data related to how a farming population would be expected to adapt to both policies and variation in key drivers of management (e.g. prices, innovation, climate), (c) the size and cost of developing temporal models, and (d) a consequent need to decrease the resolution of other parts of the model in order to consider dynamic processes (Doole et al., 2016c). The staged approach proposed in PC1 is important since it helps provide further information regarding the impacts of the policy on affected parties, before more-stringent environmental limits are imposed.

9.3 There is broad diversity in the degree to which certain mitigations for different contaminants best suit which farms. Tailoring mitigation use to individual enterprises through intensive farm planning is costly and difficult, especially at scale. Yet, Farm Environment Plans provide an appropriate regulatory response through which to target the four contaminants, as they help to ensure that mitigations achieve environmental improvement but are also suited to a particular farm and farmer context. In my opinion, they provide the most cost-effective means of resolving the uncertainty associated with estimating mitigation use and subsequent impacts on farm financial performance.

10. Help develop a strong foundation for the policy regime

10.1 The staged approach proposed in PC1 is also valuable to ensure that a strong foundation for implementation, monitoring, and enforcement is developed and applied. It takes time to design, pilot, and introduce programmes to implement environmental management, particularly over an area that is the size of the Waikato River catchment. This highlights the importance of using a considered, methodical approach to implementation.

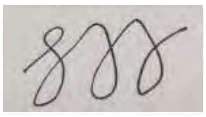
10.2 A staged approach also allows time for those affected by regulation to develop skills that help with adaptation. Environmental limits provide strong motivation for learning. However, barriers to learning remain, which can be related to climate and market variation, uncertainty, lack of scientific understanding, and complexity (Pannell et al., 2006, 2014; Kaine et al., 2017). Additionally, some managers are unwilling to deviate from established management plans, given a strong drive to repeat learned actions, even in the presence of new opportunities or constraints (Kaine et al., 2008; Gonzalez and Dutt, 2011). The current approach proposed within PC1 helps to provide motivation for learning, but without placing farm businesses at undue risk of insolvency. This is advantageous for building engagement and trust that are essential for a just transition.

10.3 The adaptation of an important sector to environmental limits can be promoted through research, development, and extension focused on cost-effective abatement. A staged approach allows time for learning from experience. Additionally, no silver bullets exist in terms of reducing the environmental footprint of agriculture given diversity between farms, farmers, and the risk of contaminant loss, across both space and time. A staged approach allows this diversity to be pragmatically considered in research, development, and extension, while also increasing the feasibility of implementing key research outcomes across a large catchment.

11. Conclusions

11.1 I support the key principles proposed in PC1 regarding restriction of the environmental footprint of the agricultural sector in the Waikato River catchment. In my professional opinion, there are a number of significant reasons why requiring the dairy sector within the Waikato River catchment to mitigate more than is currently proposed is unjustified. These include the economic importance of the sector to the region, the higher levels of cost associated with requiring more abatement, the disproportionate amount of cost that will be borne by the sector as a result of PC1, and the financial risk that this would introduce for a proportion of farms.

3 May 2019



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