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

15 February 2019

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Qualifications and experience

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 regarding the economic impacts of policies related to the improved management of water resources.

2. During this time that I worked with the New Zealand Government, I was also a Professor of Environmental Economics at the University of Waikato. Prior to these appointments, I held various positions at the University of Western Australia (Perth, Australia), where I worked for fourteen years. I have published over 60 refereed journal articles and have supervised post-graduate students for a decade.

3. The focus of my research is the economic assessment of policies and changing behaviour on private land, mainly in rural areas. This has principally involved the development and application of mathematical models of catchments, farm systems, contaminant loss, and populations.

4. While at the University of Waikato, a core part of my work program involved contributions to the Healthy Rivers Wai Ora project. 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 Healthy Rivers Wai Ora economic model (Doole, 2016b, c; Doole et al., 2016c). Hereafter, this is referred to as the *HRWO economic model*. 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 Healthy Rivers Wai Ora economic model and its application to inform decisions made for the Waikato River catchment within Plan Change 1 (PC1). These reports are: Doole (2016a, b, c, 2018), Doole et al. (2015a, b, 2016a, b, c), and McDonald and Doole (2016).

Code of Conduct

5. I have read the Environment Court's Code of Conduct for Expert Witnesses contained in Practice Note 2014 and agree to comply with it.

Scope of Evidence

6. My evidence pertains to the suitability of the HRWO economic model used by the Collaborative Stakeholder Group to decide on the policy mix that resulted in Proposed Waikato Regional Plan Change 1 – Waikato and Waipa River catchments. It addresses four general questions that analyse and confirm the suitability of the processes involved in the modelling described in paragraph 4c above:

(a) Is the model framework appropriate for this form of analysis?

(b) What is the justification for the equilibrium approach used?

(c) What is the justification for the deterministic approach used?

(d) What is the justification for the calibration method used?

Summary Statement

7. In my professional opinion, I believe that the HRWO economic model provides a sound basis for the assessment of the economic and environmental implications of different water-quality policies. Model structure and application align with best practice in economic assessments of environmental policy.

Is the model framework appropriate for this form of analysis?

8. Yes, I believe it is.

9. The model structure is loosely based on that of the Land Allocation and Management (LAM) catchment framework (Doole, 2012, 2015). The flexibility of this model is demonstrated in its broad utilisation across a number of nonpoint-pollution contexts, both nationally (Holland and Doole, 2014; Parsons et al., 2015) and internationally (Doole et al., 2013).

10. Key benefits associated with the application of the LAM framework are (Doole, 2015):

(a) Its flexible structure allows it to be adapted to diverse circumstances.

(b) The complexity of the model can be altered, depending on the quality and quantity of resources available.

(c) The model can be efficiently coded in popular nonlinear-optimisation software, such as the General Algebraic Modelling System (GAMS), that allows matrix generation.

(d) The structure of the model allows the use of a broad range of calibration techniques.

(e) Models of substantial size can be constructed (Doole, 2012).

11. The HRWO economic model described the Waikato River catchment as a landscape divided into many different partitions. This allowed a rich description of spatial and sectoral diversity, while also matching model complexity with the availability of information.

12. An alternative approach could have involved representing individual farms in the HRWO economic model. This is difficult given a lack of data, the reluctance of land owners to provide income data, model size, privacy legislation, and its high cost.

13. Another approach could have involved modelling the catchment without diversity in attenuation, farm type, production, profit, rainfall, and soil type. This method would provide misleading insight into the impacts of different policies because, in reality, diversity in these factors has an enormous impact on the way they affect economic, environmental, and social values.

14. The HRWO economic model used an automated search process to identify the set of mitigations that maximised catchment profit for a given set of circumstances. This approach aligns with adoption theory, is common in economics, introduces less bias than if human trial-and-error is used to identify suitable solutions, and allows the efficient identification of optimal strategies in complex models.

What is the justification for the equilibrium approach used in the HRWO economic model?

15. It is the most-efficient approach for this purpose.

16. No transition over time is included in the model. This equilibrium approach is valuable for several reasons:

(a) There was a paucity of information available that provided insight into how important data—such as mitigation efficacy, prices, and production—would change over time across the catchment.

(b) There was little data available that characterised how the farming population would be expected to adapt over time to different policies.

(c) There was little data available that characterised how the farming population would be expected to adapt over time to variation in key drivers of management (e.g. prices, innovation, climate).

(d) Temporal models are difficult to develop and apply, due to their size and cost.

(e) The complexity of modelling over time would necessitate decreasing the detail with which spatial diversity is represented in the assessment model. A detailed description of spatial diversity was considered important given region-wide differences in contaminant loss, attenuation, and flow. Moreover, profitability and production vary spatially, and this affects the potential economic impacts of policies at the farm, Freshwater Management Unit, regional, and national level.

What is the justification for the deterministic approach used in the HRWO economic model?

15. The model contained economic and biophysical data that is consistent with long-term averages. As such, input data is represented by a single, point estimate and not a statistical distribution. This is known as a “deterministic” approach. This is the standard approach for economic models constructed to assess water policies.

17. A deterministic approach is suitable for several reasons:

(a) Other methods are more costly and difficult to apply, while also seldom providing richer insight.

(b) It is standard in models developed for the assessment of water-quality and/or water-quantity policy. Hence, it is rare for water-policy models applied in New Zealand to represent statistical distributions for input data and a comparable level of complexity to the HRWO economic model.

(c) Deterministic models are easier to develop and apply than models that represent data described by statistical distributions. This makes them less costly and therefore favourable from a project-resourcing perspective.

(d) Detailed information describing the realistic variation evident in spatial and temporal data can be difficult and/or expensive to obtain, more so than averages.

(e) Analysis and interpretation of model output in the form of statistical distributions can be difficult. In particular, it can be difficult for stakeholders to understand it when seeking to use modelling to inform policy development.

(f) Values from the lower and upper tails of distributions can cancel one another out in many models incorporating variability in parameters. This means that the average values of output from statistical models often remain the most-salient variables of interest. This is insightful given that deterministic models provide the same information.

What is the justification for the calibration method used in the HRWO economic model?

17. It provides an accessible and efficient method of providing more realism in the way that the model responds to simulated changes in the catchment.

18. Calibration is the process whereby input data and/or model structure is adapted, so model output better describes reality. This includes replicating the current state and improving the realism of the predicted response to regulation. Calibration is necessary because many models—such as the economic model applied in the HRWO policy-development process that resulted in PC1 —often do not include all factors that impact land-use decisions (e.g. existing skills, preferences). Land use is often quite inflexible because of existing financial, human, natural, and physical capital associated with a given land parcel. Optimisation models of catchments can overstate the flexibility of land use because they do not represent all of these things that guide these decisions.

19. Two primary means exist to calibrate optimisation models of the kind applied in the HRWO process.

(a) One involves manipulating the relative profitability of each landuse to improve the degree to which the model reflects the current state (e.g. Daigneault et al., 2012). This method is known as positive mathematical programming (PMP) (Howitt, 1995).

(b) Another involves making sure that model outcomes are within the set of historical observations (Chen and Onal, 2012).

20. PMP methods involve non-statistical or statistical estimation. The first is widely applied in New Zealand in the NZFARM model (Daigneault et al., 2012). Nonstatistical methods have been strongly criticised given their lack of theoretical basis (Heckelei and Wolff, 2003), arbitrary selection of calibration data (Heckelei et al., 2012), failure to utilise data estimated outside of the current state (Heckelei and Britz, 2000), and departure from profit data estimated for each land use (Doole and Marsh, 2014). For these reasons, this approach is not employed here.

21. In contrast, statistical PMP methods are the state-of-the-art for model calibration. However, these require rich historical land-use data and knowledge of advanced statistical-estimation techniques; neither of which were available here. Both PMP approaches are also difficult to explain to stakeholders, which complicates the use of model output to guide policy development.

22. Historic land-use patterns can be used to constrain land-use changes to more-realistic levels. This approach was deemed appropriate in the HRWO economic model because it is straightforward to code, much easier to formulate and less prone to error than forcing calibration through the use of arbitrary calibration functions (Doole and Marsh, 2014), draws on regionally-specific data, and is the only land-use calibration method that has a rich theoretical justification (Chen and Onal, 2012).

23. Historic land-use patterns observed for a distinct region (i.e. sub-catchment) provide specific insight into the type of land-use change that can occur there. Indeed, these patterns provide spatial information regarding the implicit aggregate and biophysical factors that guide land-use change within this area. Using this historical information within the HRWO economic model allows the specification of a well-behaved aggregate model, despite lacking data for individual farms (Chen and Onal, 2012).

24. To use this approach, historic land use for each sub-catchment across 1972–2012 was drawn from the work of Hudson et al. (2015). The optimisation procedure then identified the best weighted average of these historic land-use sets that attained the environmental limits set out by each scenario at least cost.

25. Further, transition costs were also incorporated into the model, to ensure that the economic implications of changing land use were adequately described.

Conclusion

26. In my opinion, the economic model in the HRWO process to assess the biophysical and economic impacts of different means to improve water quality in the Waikato River catchment is consistent with good practice.

Dated: 15 February 2018

Name: Dr Graeme John Doole

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