BEFORE THE PROPOSED NATURAL RESOURCES PLAN HEARINGS PANEL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of Water quality
AND	
IN THE MATTER	of Right of Reply evidence to matters raised during Hearing Stream 4

STATEMENT OF RIGHT OF REPLY EVIDENCE OF Alexander (Sandy) Hewgill Elliott ON BEHALF OF WELLINGTON REGIONAL COUNCIL

TECHNICAL – Water quality

4th May 2018

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1. INTRODUCTION

1.1 My name is Alexander (Sandy) Hewgill Elliott. I am a water quality modeller with 30 years' experience in water quality modelling and over 20 years' experience specializing in catchment modelling for water quality. I have been employed for 19 years at the National Institute of Water and Atmospheric Research (NIWA), where I am Principal Scientist for Catchment Processes and Programme Leader for the Causes and Effects of Water Quality Degradation programme. I have a Ph.D. in Environmental Engineering Science from the California Institute of Technology and a B.E. in Engineering Science from the University of Auckland. I am a member of the New Zealand Hydrological Society, the New Zealand Freshwater Sciences Society, and the International Environmental Modelling and Simulation Society. I am an expert with regard to mathematical modelling of contaminant generation and transport in catchments and streams, with particular emphasis on catchment modelling for diffuse sources of water quality degradation. I have developed and used a range of catchment models at a range of spatial and temporal scales, routinely applying these to inform catchment planning and policy development in New Zealand. I have also conducted associated monitoring, field experiments, and data analysis.

1.2 In my primary evidence for HS4, I presented evidence in respose to Dr Adam Canning's HS1 evidence, relating to setting region-wide nutrient limits as a means for raising macroinvertebrate community index (MCI) values to meet target values in Wellington streams and rivers.

1.3 At the HS4 hearing, I also provided evidence, to address Dr Canning's HS4 evidence.

1.4 I have subsequently held discussions with Dr Canning to discuss areas requiring clarification, and identify points of agreement disagreement. A joint witness statement was produced (Appendix A).

3. CODE OF CONDUCT

3.1 I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note and that I agree to comply with the code. My evidence in this statement is within my area of expertise. I have not omitted to consider material facts known to me that might alter to detract from the opinions which I express.

4. SCOPE

4.1 This Right of Reply evidence summarises my understanding of the proposed load limits as proposed in Dr Canning's HS4 evidence, taking into account my caucusing with Dr Canning, as well as having regard for Percy and Cooper's evidence (HS4-S75, pages 103-106). I aim to summarise, clarify and provide my opinion on the proposed limits, also taking into account my caucusing with Dr Canning.

5. SUMMARY OF THE METHOD PROPOSED BY DR CANNING IN HS4

5.1 The approach proposed by Dr Canning involves several steps for determining the in-stream load target, for each of nitrate-nitrogen (NO3) and dissolved reactive phosphorus (DRP):

1. The measured concentration is determined for each of a set of water quality monitoring sites.

2. The desired (or target) concentration for each site is also determined (which is the subject of separate evidence).

3. The measured in-stream load (tonnes per year) at the monitoring site is estimated from flow and water quality information available for the site.

4. The target in-stream load is then determined the proportion reduction of concentration required. So, for example, if the target concentration is 10% less than the measured concentration, then the target in-stream load is 10% less than the measured in-stream load.

These steps are illustrated in Figure 1 below.

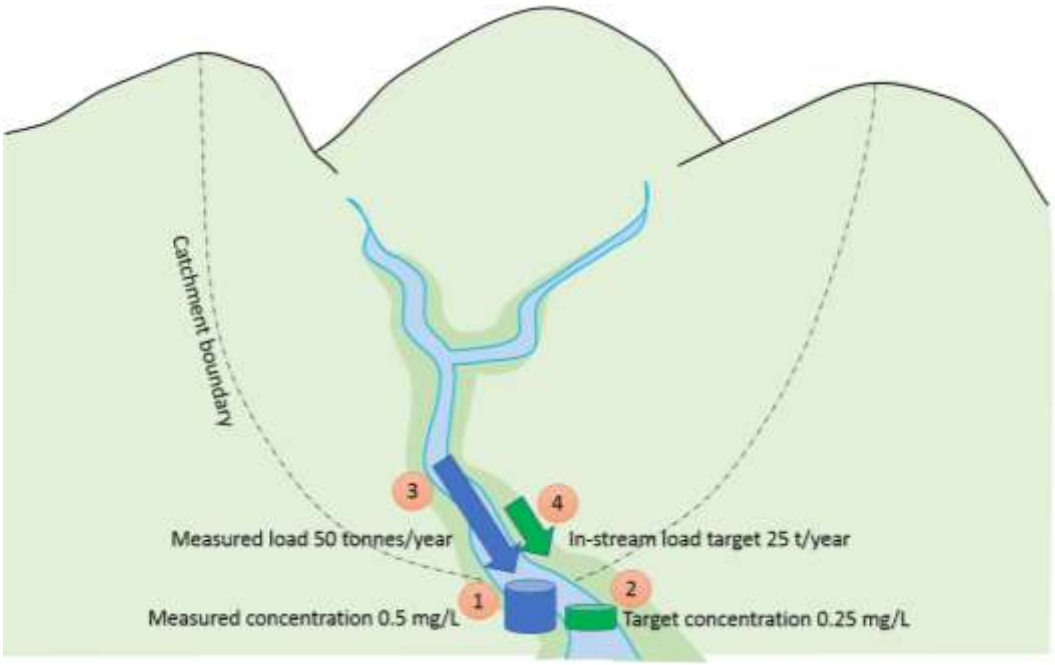

Figure 1: Summary of the steps in the proposed method for determining the target in-stream load, for a hypothetical catchment and stream.

5.2 This in-stream load then becomes the target contribution of the associated upstream catchment area to the load at the monitoring station. An exception is if there is a monitoring station in the upstream catchment, in which case adjustments are made to the target load to take account of loads entering from the upstream site, as illustrated in Figure 2.

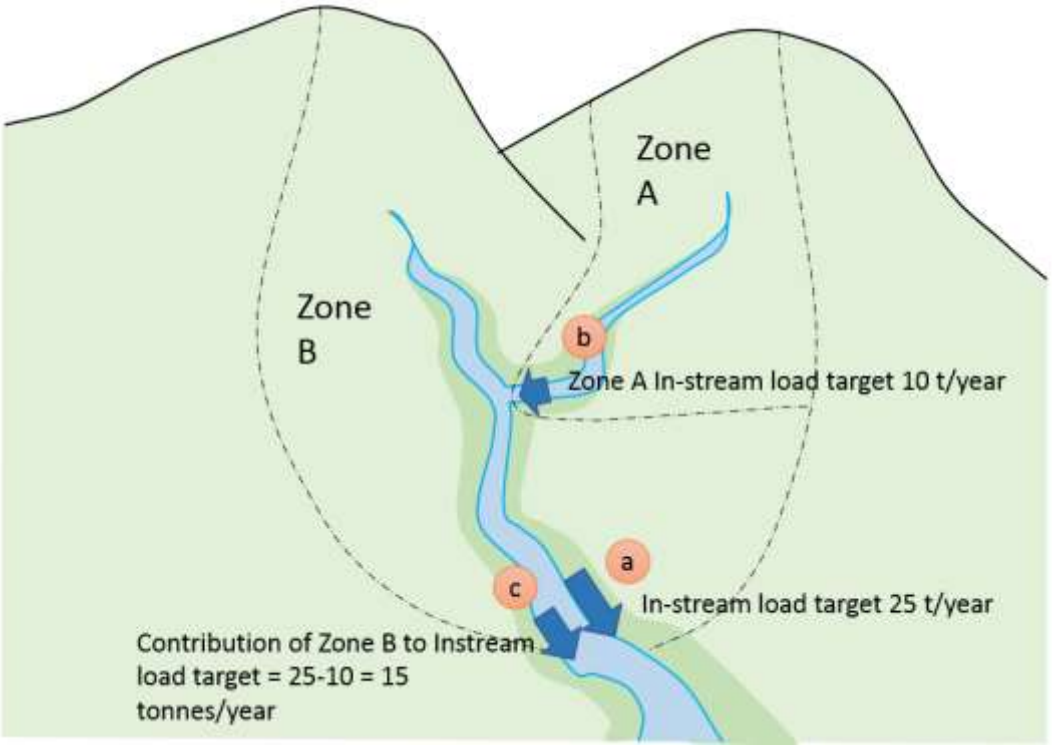

Figure 2: Modification to contribution from zones to take account of upstream subcatchments.

6. COMMENTARY ON THE METHOD

6.1 The proposed method only provides in-stream loads for a specific set of zones associated with monitoring stations. Those zones do not cover the entire Wellington Region. Hence, the proposed method does not provide a basis for managing loads in the areas outside those zones. The area outside these zones is substantial, such as the lower Ruamahanga, as shown in Figure 3.

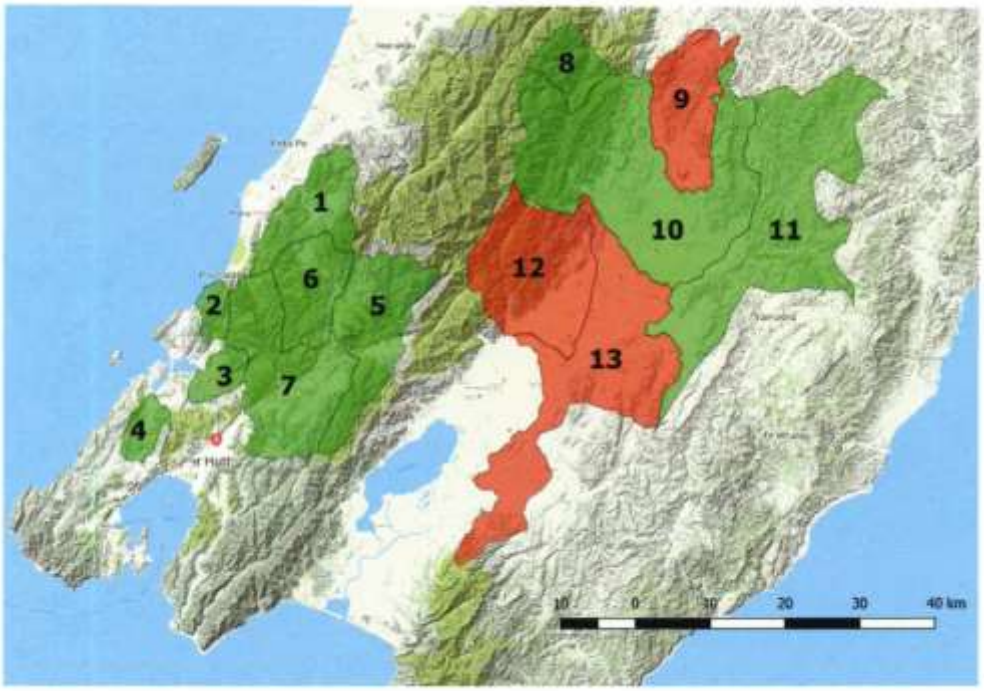

Figure 3: Areas included in the analysis (copy of Figure 2 from Dr Cannings's HS1 evidence).

6.2 The proposed method entails several approximations. For example:

a) Estimation of measured load is subject to uncertainties. For example, three methods of load calculation are used by Dr Canning, and then the average of the three methods is used as the overall estimate. However, the methods differ, often by a factor of two, which provides an indication of the degree of uncertainty associated with estimating the load from measured flows and concentrations. The paper by Dr Ton Snelder[1] emphasises such difficulties, and the large errors sometimes associated with load estimation. These are mainly caused by errors arising from estimating concentrations at times other than the times of actual sampling (typically monthly). There are also errors associated with measuring concentrations and flow themselves.

[1] Snelder, T., McDowell, R., Fraser, C., 2017. Estimation of catchment nutrient loads in New Zealand using monthly water quality monitoring data. JAWRA Journal of the American Water Resources Association 53, 158-178.

b) The assumption of proportionality between concentration reduction and load reduction introduces uncertainty. For example, when source loads are modified in an effort to reduce loading, they may affect concentrations and loads differently. Concentrations of contaminants tend to be higher during storms than during normal flows, so that load reduction methods targeted at storm conditions may not significantly affect concentrations during normal flow conditions (e.g. median concentrations). The uncertainty associated with this aspect of the method is not known, but could be substantial.

6.3 While all load calculation methods entail uncertainties, the uncertainties may have important implications in a management context. For example, a 10% error in load estimation would be considered small in the context of load estimation, but a a 10% source load reduction has potentially important implications for land use management.

6.4 The method proposed in Dr Canning's evidence does not address how the loading from land can be related to the in-stream load. The method simply states how much the contaminant sources can contribute to the in-stream load. Many factors must be considered when linking sources on the land to the load in the stream. For example, contaminants may be stored long-term (decades or more) or removed from the system (decay or loss to the atmosphere). Also, in-stream loads are expressed in terms of NO3 or DRP, whereas source loads are usually in terms of total nitrogen (TN) and total phosphorus (TP), of which NO3 and DRP are only a part. To effectively manage the sources of contaminants, the methods used should more directly relate sources to in-stream loads — such methods are not provided in Dr Canning's HS4 evidence. The additional steps required to make such linkages are likely to introduce several uncertainties, as agreed in the caucusing statement with Dr Canning.

8. CONCLUSIONS

8.1 Conferencing with Dr Canning has resulted in an agreed understanding of the method for load assessment as presented by Dr Canning in earlier evidence.

8.2 Key steps are summarised in my evidence, to assist with communicating the core of the method.

8.3 The proposed method does not extend to establishment of sources of contaminants; it only addresses setting in-stream loads, or, more specifically, the contribution of zones to the in-stream loads.

8.4 While the proposed method is logical and reasonable, it contains several limitations, approximations, and areas of uncertainty which may have significant implications for management of source loads.

8.5 A significant portion of the region is not covered by the proposed method.

APPENDIX A.

CONFERENCING STATEMENT BETWEEN ADAM CANNING AND ALEXANDER ELLIOTT

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of Water quality and stormwater – Hearing 4

AND

IN THE MATTER of the Proposed Natural Resources Plan for the Wellington Region

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EXPERT CONFERENCING JOINT WITNESS STATEMENT TO THE HEARING PANEL

TOPIC: NUTRIENT LOADS

DATE: 20 MARCH 2018

INTRODUCTION

1. This joint witness statement (JWS) was written following discussion between the experts to clarify their positions for the hearings panel.
2. This joint witness statement relates to the conferencing topic of **nutrient loads**
3. A conferencing discussion was held on **02 March 2018** via teleconference. This witness statement was then circulated, refined and agreed by email between the participants.
4. Participants were:
   - Dr Alexander (Sandy) Elliott – Principal Scientist, NIWA
   - Dr Adam Canning – Research Scientist, Wellington Fish and Game Council
5. In preparing this statement, the experts have read and understood the Code of Conduct for Expert Witnesses as included in the Environment Court of New Zealand Practice Note 2014.

    1. Dr Canning's hearing stream one (HS1) evidence proposed a method to calculate the annual nutrient source loads (e.g. tonnes per year root-zone leaching losses) to meet in-stream water quality targets. Some aspects of this system were clarified and revised in Dr Canning's evidence for HS4.
    2. Source loads for sub-catchments were estimated by applying source rates per unit area per land-use types. These source estimates were derived from OVERSEER (for pastoral activity) or generic literature estimates (for non-pastoral non-point sources, e.g.,

forestry and urban) and are measured as Total Nitrogen and Total Phosphorus (these were incorrectly worded in Dr Canning's evidence at HS1 as Dissolved Inorganic Nitrogen (DIN) and Dissolved Reactive Phosphorus (DRP)). The in-stream loads were determined for Dissolved Reactive Phosphorus and Nitrate-Nitrogen.

3. The experts agree that Dr Bright's estimates of root-zone leaching for the Ruamahanga Whaitua is likely to provide more refined estimates for that catchment, although the estimated root-zone leaching load for the Ruamahanga catchment and Dr Canning's HS1 estimates were very similar.
4. The method assumed that the sources for a given sub-catchment should be reduced in proportion to the desired reduction in-stream load (after subtracting inputs from upstream subcatchments). In turn, the in-stream load reduction should be reduced in proportion to the desired reduction in concentration at the chosen monitoring site. So, for example, if the monitoring site (which drains the subcatchment/zone) requires a 30% reduction in nitrate-nitrogen concentration, then a 30% reduction in root-zone leaching Total Nitrogen load is also required, if there are no upstream sub-catchments.
5. The experts agree that, in the absence of a thorough understanding of nutrient uptake (attenuation) via soil, groundwater, riparian and in-stream processes, assuming a proportional reduction is a pragmatic and common approach, albeit coarse. Currently, there is limited quantitative information on attenuation processes at catchment or regional scale.
6. The source load calculation method did not account for differences in water quality within a zone. The aim was to achieve compliance at the most downstream point of the zone (i.e., the monitoring site). The experts agree that this may result in some streams within a zone being over and others being under the desired concentration. The resolution of the zones/FMUs were limited to sites where both a flow recorder and concentration monitoring exist.
7. The experts agree that where flow monitoring occurs in a slightly different location from the concentration monitoring site, then the concentration monitoring site should be the site of load measurement as it is easier to account for differences in flow between sites.
8. Dr Canning's hearing stream four (HS4) evidence updates the in-stream nutrient loads but does not update the source loads (which would need updating if they are to be used in the plan). The updated in-stream nutrient loads correct the MCI objective error detected by Dr Elliott in the HS1 evidence.
9. There are parts of the Wellington region where loads (source loads or in-stream) have not been calculated because there are not suitable measured data. The experts agree that loads could be estimated for these areas using modelled data; however, this may come with some additional uncertainty.
10. The allowable load contribution for a zone is the desired measured load less the desired load of any upstream zone.

Addressing the items requiring clarification raised in Dr Elliott's evidence

11. Point: *"Methods for allowing for the influence of point sources are not presented"* and

    In Dr Canning's HS1 evidence, point source loads were subtracted from the in-stream river loads before calculating the in-stream load associated with non-point sources. The experts agreed that this approach is appropriate.

    The experts agree that the in-stream loads presented in Appendix D of Dr canning's HS4 evidence did not require point source loads to be estimated. The in-stream load limits in Appendix D are intended to be applied regardless of load origin.

12. Point: "*Methods for quantifying non-pastoral non-point sources of nutrients are unclear."*

    Non-pastoral non-point sources (e.g., urban), as explained above, were accounted by using generic literature estimates of leaching. The experts agreed that this is of consistent resolution with the pastoral estimates.

13. Points: *"Methods for calculating on-land loading for DRP and the associated in-stream loading are not fit for purpose. This was because a) The method for determining DRP losses were unclear; b) The method for determining DRP loading from land was inappropriate because Overseer does not predict losses of DRP"* and *"The analysis does not explicitly take into account the fact that only a portion of total nitrogen loading is in the nitrate form."*

    As also mentioned above to clarify, Dr Canning's source load calculation in his HS1 evidence used TP not DRP and TN not DIN. Root-zone TP and TN allocations were reduced by the proportion desired for in-stream DRP and nitrate-nitrogen concentrations. The experts agreed that this is pragmatic assumption.

Summary of the uncertainties from Dr Canning's evidence on loads

14. The experts agree that whilst the methods used to derive the source loads can be used for obtaining a preliminary estimate, they are coarse and include the following uncertainties:
    a. The estimates assume that all farms of the same type (i.e., sheep and beef, or dairy) have similar leaching rates. However, there is likely to be considerable uncertainty from this extrapolation, as farms vary substantially in their fertilizer application, stocking rates, rainfall, irrigation, soil and land-form. The experts agree that the collection of more data and/or the adoption of a more complex modelling approach, such as the work by Dr Bright, this uncertainty could be reduced.
    b. The leaching estimates were derived from OVERSEER. OVERSEER provides an estimate of long-term leaching for a farm, it does not estimate leaching at the week or season scale. OVERSEER has not been comprehensively validated, with preliminary uncertainty estimates for the 2001 version being approximately 20-30% (Ledgard & Waller, 2001) – it is unknown whether the uncertainty of the current version differs. Furthermore, OVERSEER has regular within-version updates

that can also change estimates. The experts agree that should source calculations be based on OVERSEER, then Council will need to regularly assess the impact of updates, and when needed update numbers to be consistent with the desired percentage reduction.

c. Whilst assuming that reductions in sources will lead to the corresponding proportional reduction in in-stream concentrations is a pragmatic approach given the lack of detailed quantitative knowledge of attenuation, this assumption may not be accurate. For example: there may be background additional sources which remain constant regardless of on-farm losses (such as dissolution of phosphorus from minerals in groundwater); sources of phosphorus could enter streams predominantly during storms whereas concentrations of interest are predominantly during baseflow; and the ratio of nitrate to total nitrogen in a stream can increase as loading increases. The degree of coarseness of the calculations is difficult to predict, because there are not many measurements of changes in both sources and concentrations.

Signed on 20 March 2018

Sandy Elliott

Adam Canning