

**IN THE ENVIRONMENT COURT
AT WELLINGTON**

**I TE KŌTI TAIAO O AOTEAROA
KI TE WHANGANUI-A-TARA**

UNDER	the Resource Management Act 1991
IN THE MATTER	of appeals under sch 1, cl 14(1) against the decision of Manawatū-Whanganui Regional Council on Plan Change 2 to the One Plan
BETWEEN	TE RUNANGA O RAUKAWA ENV-2021-WLG-20 NGĀTI TURANGA ENV-2021-WLG-21 ANDREW DAY ENV-2021-WLG-22 WELLINGTON FISH AND GAME COUNCIL ENV-2021-WLG-23 Appellants
AND	MANAWATŪ-WHANGANUI REGIONAL COUNCIL Respondent

**WILL-SAY STATEMENT FOR EXPERT CONFERENCING – DR JEAN-PAUL
TAVERNET**

Dated: 22 December 2023

A. INTRODUCTION

- [1] My full name is Jean-Paul Jean-Pierre Tavernet.
- [2] I am the Principal Modeller for Overseer Limited. I have held that role since July 2022, and prior to that I was a Senior Modeller in the same team since October 2020.
- [3] I hold a Ph.D. in Particle Physics from Denis Diderot University (Paris Cité University)
- [4] I am a physicist with a career of 27 years in modelling complex phenomena. From 1996 to 2020, I was an associate professor and then a tenured professor at Pierre et Marie Curie University (Sorbonne University). I was involved in modelling phenomena and data analysis in particle physics and astroparticle physics for international research organisations. Since 2020, I have participated in improving the Overseer model in collaboration with expert scientists in various fields such as soil hydrology, climate data or the uncertainties associated with Overseer estimates.
- [5] I have prepared this will-say statement for the purposes of expert conferencing. It is intended to address the questions directed to me from paragraph [8] of the Court's Minute, dated 6 December 2023.

B. CODE OF CONDUCT

- [6] I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023. This will-say statement has been prepared in accordance with that Code. I confirm that I have not omitted to consider material facts that might alter or detract from the opinions that I express. Any evidence I give will be within my area of expertise, except where I state I am relying on the opinion or evidence of other witnesses. I understand it is my duty to assist the Court impartially on relevant matters within my areas of expertise.

C. INFORMATION & METHODOLOGY

- [7] In preparing this will-say statement, I have reviewed the following information:
 - (a) Court's Minute dated 6 December 2023
 - (b) SOE of Dr James Antony Hanly on Overseer version changes and Table 14.2

- (c) SOE of Dr David John Horne on farm management practices
- (d) SOE of Dr Paul Frederick le Miere on pastoral farm system
- (e) SOE of Alison Mary Dewes for the wellington fish and game council

[8] I have also referred to publications listed in the references section.

D. CONFERENCING

[9] I provide an outline of my position on the questions posed by the Court below.

Confirmation from the author of the model performance report that the data in that report can and has been used appropriately to found Dr le Miere's calculations together with any further evidence that the witness considers would be of assistance to the Court regarding the veracity of Overseer predictions.

[10] I am the author of the report entitled 'model performance' which finalises the Overseer redevelopment programme (ORP). This programme was established in collaboration between the Ministry for Primary Industries (MPI) and Overseer to address the concerns reported by the Science Advisory Panel (SAP) in 2021. ORP is based on the recommendations from the Technical Advisory Group (TAG) established by MPI consisting of scientific experts, regional council representatives, and policy personnel from MPI and the Ministry for the Environment (MfE). Details of the program timeline and conclusions are available in the reference (MPI, 2023).

[11] The performance report is based on the study carried out to assess the model performance against measured data. The analysis is focused on evaluating the goodness-of-fit of the Overseer model for different agricultural enterprises rather than quantifying estimate uncertainties. By comparing modelled estimates with real-world measurements across a range of nitrogen (N) leaching values, the study aims to evaluate the model's performance.

[12] The performance report recalls that measuring N leaching for an experiment is remarkably difficult, particularly at the scale of a paddock or a plot. For example, in a grazed system, the spatial distribution of urine patches is not uniform across the entire field, making the measurement of N losses considerably complicated. As this distribution can influence the movement of nitrates, it is crucial to choose an appropriate sampling method. More generally, all measurement methods have uncertainty relating to sampling, sample preparation and assay techniques, and so it is crucial to understand these limitations when estimating the mean and uncertainty of N leaching

measurements. In summary, experimental N leaching values are inherently measured with uncertainty and cannot be assumed to be 100% accurate.

- [13] Moreover, the experimental results come from trials designed for specific purposes detailed in the appendices of the performance report - not for the purpose of validating a model such as Overseer. Thus, accurately modelling the trials in Overseer, as described in Smith et al. (2020) requires careful consideration of when and how information about climate, experiment management, livestock, and nitrogen inputs is entered.

- [14] The comparison of the Overseer model N leaching estimates with experimental data shows a strong linear correlation. The accuracy and goodness of fit of the Overseer model are quantified by three independent statistical tests following the methodology described in Moriasi et al. (2007):
 - (a) NSE (Nash-Sutcliffe Efficiency) is widely used and accepted to assess the predictive power of models, or how well the model's predictions match observed data. A value closer to 1 indicates a perfect fit.

 - (b) RSR (Ratio of the Root Mean Square Error (RMSE) to the Standard Deviation of Measured Data), based on the RMSE, is used to measure the relative error of a model in predicting quantitative data. A value closer to 0 indicates better model performance.

 - (c) p-bias (Percent Bias) provides the average tendency of a model to overestimate or underestimate the observed data, expressed as a percentage. A value of 0 indicates no bias.

- [15] In version 6.5.4 (December 2023), the Overseer model performance is rated 'good' to 'very good' depending on the statistical test used for the studied grazing systems (an improvement compared to the previous version) and ranges from 'satisfactory' to 'very good' according to statistical tests used for cropping systems. This analysis provides evidence of the overall good performance of the model in predicting N leaching, suggesting that it reliably reflects the key factors influencing nitrogen leaching in the cases presented. Just like all models, Overseer predicts N leaching with an uncertainty outlined in Tavernet et al. (2022b).

- [16] In summary, due to inherent limitations in the data used in the performance and validation reports, these data cannot be reliably used to estimate uncertainties in Overseer predictions. Therefore, if Dr. Miere's goal is to

quantify the uncertainties in Overseer, it would be inappropriate to rely on the report's data. A study dedicated to the uncertainties of Overseer predictions was carried out and reported in Tavernet et al. (2022b).

Clarification from the author of the validation report as to which data points on Figure 1 are from farms in the Manawatu/Whanganui region and what are the rainfall and soil characteristics in each case?

- [17] I am not the author of the validation report, but I would like to point out that the same dataset was used in both analyses. However, the data was treated completely independently. In fact, this dataset brings together all the measurements carried out in NZ with a minimum quality necessary to allow a comparison with models such as Overseer. This dataset is unique and, therefore, has several limitations described in Selbie et al. (2020).

An analysis by the relevant expert(s) of what the data contained in both the model performance report and validation report can tell us in respect to the veracity of Overseer predictions.

- [18] The data for the model performance report and the validation report (Figure 1) come from the same dataset, which has known weaknesses as described in Selbie et al. (2020), but it contains the measured N leaching dataset for grazing systems, with which each model can be compared. Measures from cropping systems were also used, increasing the number of soil types and climate ranges studied. For these two systems, the Overseer performance has a rating from 'satisfactory' to 'very good'.
- [19] The veracity of model predictions can be defined by a quantification of:
- (a) Accuracy: measure how closely Overseer's predictions align with observed data from various agricultural system
 - (b) Precision: assess the consistency/reliability of Overseer's predictions across multiple trials
 - (c) Bias: overestimates or underestimates of observed data
 - (d) Uncertainties: range of confidence associated with Overseer's predictions
- [20] Points (a) to (c) are quantified in the performance report by comparing Overseer's predictions to all available good quality measurement data. In the

latest version of Overseer (6.5.4, December 2023), the values of the performance metrics for the grazing systems are: NSE=0.68 (good), RSR=0.56 (good) and pbias=4% (very good). Together these results demonstrate good performance of the Overseer model in predicting how changes in farm management practices impact N-loss outcomes.

- [21] Point (d) is reported in Tavernet et al. (2022b) and summarised in the following.

- [22] Model uncertainty analysis focuses on the range of possible results the model could produce, given the associated uncertainties in its inputs, parameters, and assumptions. For this purpose, the model is run multiple times with different combinations of input parameters or assumptions. A distribution of possible results is thus generated, which can be used to quantify the uncertainty in the model's predictions.

- [23] Three complementary analytical approaches were carried out to assess the uncertainties associated with the Overseer model's N-loss estimates at the farm level:
 - (a) Local sensitivity analysis (LSA) identified the individual model parameters that most significantly alter Overseer's N-loss estimate at the farm level (Tavernet et al., 2022a).

 - (b) Global sensitivity analysis (GSA) identified the magnitude of interactions between the most influential parameters on N-loss estimates at the farm level (Tavernet et al., 2022a).

 - (c) Uncertainty analysis (UA) quantified the overall uncertainty in the N-loss estimates, focusing on the propagation of uncertainties associated with key input parameters (climate and soil) (Tavernet et al., 2022b).

- [24] The results of LSA identified that, of the parameters analysed, Overseer's N-loss estimate was most sensitive to changes in the climate and soil parameters across all types of NZ farm systems. The GSA revealed minimal interactions between studied parameters, meaning that variations in N-loss estimates were mainly due to the independent effects (additive effects) of the key input parameters. This highlights that the uncertainties in the key parameters (climate and soil) will dominate the uncertainties associated with the N-loss estimates.

- [25] The combined uncertainty in soil and climate inputs for the Overseer N-loss model averaged 27% across diverse NZ farm systems. Notably, uncertainty was higher at low N-loss values ($35 \pm 10\%$, < 10 kg N/ha/yr) and lower at high values ($15 \pm 5\%$, > 100 kg N/ha/yr). Table 1 summarises the average uncertainties due to climate and soil input data uncertainties. Additional input parameter uncertainties were minimal (1%) based on the LSA.

N-loss at farm level (kg N/ha/yr)	Average relative uncertainty (%)
< 10	35
≥ 20	27
≥ 40	25
≥ 60	22
≥ 80	19
≥ 100	15

Table 1- Summary of the average uncertainties due to climate and soil input data uncertainties.

- [26] These uncertainty values and ranges are comparable to other models in the field that have published their uncertainty analysis. Any model such as Overseer, Agricultural Production Systems sIMulator (APSIM) or Fonterra Nitrogen Risk Scorecard (NRS) has uncertainty associated with its predictions.
- [27] On the other hand, Overseer continues to collaborate with scientists to refine its algorithms, participates in SLMACC projects to expand the set of measured data and integrate new environmental mitigation technologies and finally will develop scenario analyses to strengthen confidence in the model.

Confirmation from Dr le Miere or other relevant expert(s) that the example in Appendix 1 accurately or otherwise demonstrates an effect of Dr le Miere's calculations, ie:

Is there a likelihood that uncertainty in Overseer predictions means that some farms with predicted CNLMs greater than the relevant Table 14.2 limits have actual nitrogen losses that are less than the 4 relevant limits? If so, please quantify the extent of the issue, including numbers and scale of prediction errors, as far as possible.

- [28] The actual N-loss value at the farm level that Overseer attempts to predict is unknown in an exact sense because of the uncertainties associated with sample-based measurements (including whether the sample is representative and homogeneous, whether the sample is handled correctly, whether the test method is properly calibrated, and so on). Models like Overseer are inherently imperfect due to factors like simplified assumptions, incomplete calibration data, and simplifications of the real world. The

prediction rarely perfectly matches the actual real-world value. Model uncertainty provides a range within which the actual value will lie with some probability. Therefore, working with a strict upper limit on a predicted value with inherent uncertainties requires careful interpretation, because even if the range within which the actual value could lie (confidence interval at 90% for example) is determined, it is not 100% certain that the true value is in this range.

- [29] The setting of a strict upper limit on predicted values is possible; it is necessary to balance environmental protection and potential impacts on farms. This involves accepting some risk of false positives (incorrectly exceeding the limit) and establishing an acceptable trade-off between environmental costs and agricultural consequences through a thorough risk assessment.

- [30] Commissioner Hodges has prepared an appendix for Minute of the Environment Court (6 December 2023) setting out possible outcomes from Overseer over-or under-estimating leaching losses. Different scenarios are presented, and given what has just been said, there is a certain probability that these scenarios will come true.

- [31] Using the example of a farm on LUC 1 or 2 land with a CNLM limit of 40 kgN/ha/y: If the farm's Overseer prediction was 50 kgN/ha/y, the associated uncertainty is on average around 22% (Table 1). Assuming a normal distribution with a mean of 50 kg N/ha/y and an uncertainty of 22%, the probability that the actual value is less than 40 kgN/ha/y is approximately 0.0863, or 8.63%. If the prediction was 60 kgN/ha/y, the probability that the actual value is less than 40 kgN/ha/y is approximately 0.3%.

Is there a likelihood that uncertainty in Overseer predictions means that some farms with predicted CNLMs less than the relevant Table 14.2 limits have actual nitrogen losses that are greater than the relevant limits? If so, please quantify the extent of the issue.

- [32] This scenario is possible with a certain probability depending on the Overseer estimation value. For example, if the Overseer prediction is as low as 20 kgN/ha/y, using the normal probability density function (PDF) to model the distribution of possible actual values around the predicted value of 20 with an uncertainty of on average 27% (Table 1) the probability that the actual value is greater than 40 kgN/ha/y is approximately 1.3%. This calculation methodology is valid for all models, not just Overseer.

Confirmation or otherwise from the relevant expert that Overseer predictions for farms in the priority subzones are based on appropriate calibration either locally or in other areas with generally similar biophysical characteristics.

- [33] The Overseer model uses farm geolocation to identify soil properties and 30-year average monthly climate data. It was originally calibrated against wide ranging field measurements for the characteristics of New Zealand farm systems. It is therefore suitable for modelling farm systems managed by the Horizons Regional Council.

Any other relevant technical information the experts consider the Court should take into account regarding the veracity of Overseer predictions.

- [34] Despite its inherent uncertainties, Overseer, like other models, remains a powerful tool in several domains, such as:
- (a) Quantifying relative trends and changes: despite uncertainties in absolute N-loss estimates, Overseer reliably captures relative changes within similar farms, enabling the evaluation of different scenarios, interventions or policies based on their comparative impact.
 - (b) Scenario planning and risk assessment: Overseer can be used to assess potential risks and plan for various scenarios at the farm level or for several farms with similar characteristics.
 - (c) Comparison of environmental performance across farms of the same type: Overseer enables the N-loss performance of a farm to be compared to that of other farms of the same type (e.g., dairy) in the same region, in a relative sense. This enables the riskier farms to be prioritized for remediation. Importantly, this strategy for identifying the riskiest farms will remain effective even with future Overseer model updates because it does not require Table 14.2 to be recalibrated. The upper quartile of riskiest farms (greatest estimated N-loss relative to other farms) is likely to remain close to the same set of farms in all versions of the Overseer model. Individual farms may move slightly relative to others but overall, the set of riskiest farms should remain fairly consistent.
 - (d) The power of the Overseer database of farms. Overseer has a large (approximately 15,000 farms nationwide) and growing database of

modelled farms. As this number of farms increases, the confidence continues to grow in identifying the riskiest farms for a region and enterprise type in a relative sense (helping to identify farms most in need of environmental mitigation).

[35] To avoid comparison with limits based on absolute values, the implementation of a relative approach can be considered allowing the objectives and support to be adapted to each agricultural operation. This can take many forms – many of which are detailed in Freeman et al (2016), but the two most commonly utilised are:

- (a) Relative reduction, as used in several zones within Canterbury, where relative risk of N loss is determined based on factors such as stocking rate, irrigated area, and/or area of winter cropping. Depending on the starting point, farm systems are then required to reduce their N losses by a relative amount, e.g. 25%. As Overseer versions change, the absolute numbers may change, but the direction of travel and required reduction percentage remains intact.
- (b) Reduction to a percentile – as outlined in the original PC1 in Waikato, where farms above the 75th percentile for N loss are required to reduce their loss level to that at the 75th percentile. While this may create some overs and unders, these may be deemed acceptable due to the overall direction of travel and their position at the upper end of N loss levels.

[36] Finally, I would like to recall to the court that no other model has been subject to the same degree of widespread validation and scrutiny as Overseer and that, as a result, good modelling practices have been improved, making the Overseer model the leading tool in NZ for assessing N-loss impact from farm management practices. Here are the advantages across some fields:

- (a) The assumptions and limitations are published and well-known
- (b) All technical manuals of the model are publicly available
- (c) Monitoring and updating the model with the most recent published data
- (d) Continuous improvement via collaborations with scientists
- (e) Validation of the model

- (i) Comparisons with real data
 - (ii) Sensitivity analyses, local and global
 - (iii) Uncertainty analysis
 - (iv) Scenarios testing
- (f) Collecting high-quality data: participation in the SLMACC projects
- (g) Rural professionals trained to minimise abuse and maximise the benefits of Overseer
- (h) In addition, Overseer estimates the losses of different nutrients as well as GHG emissions, making it possible to assess in tandem the combined pollution effects on water and emissions when, for example, a mitigation is introduced. This helps avoid pollution swapping where a mitigation might for example reduce one type of pollution but increase another.
- [37] As the prominent statistician Prof. George E. P. Box famously said: “All models are wrong, but some are useful.” While no model perfectly mirrors reality, I submit to the court that for managing changes across New Zealand farm systems to improve water and air quality, Overseer is the most useful model available.

22 December 2023

Dr Jean-Paul Tavernet

E. REFERENCES

- Freeman, M, Robson, M, Lilburne L, McCallum-Clark, M, Cooke, A, & McNae, D. 2016. Using OVERSEER in regulation – technical resources and guidance for the appropriate and consistent use of OVERSEER by regional councils, August 2016. Report prepared by Freeman Environmental Ltd for the OVERSEER Guidance Project Board. Retrieved from https://assets.ctfassets.net/bo1h2c9cbxaf/4IEgE1Oe5I223NhbDmJsi/1b2fa72385d052f06abe5126765f24ac/Using_OVERSEER_in_Regulation.pdf

- Moriasi, D., Arnold, J., Liew, M., Bingner, R., Harmel, R., & Veith, T. (2007). Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations. Transactions of the ASABE, 50.
- MPI (August 2023). Overseer Redevelopment Programme Report. New Zealand: MPI. Retrieved from <https://www.mpi.govt.nz/dmsdocument/59020-Overseer-Redevelopment-Programme-Report>
- Selbie, D., Smith, C., Mercer, G., & Shepherd, M. (2020). Evaluation of the OVERSEER® pastoral block N model (v.6.3.1): 1. Selection of farmlet experiments. Overseer Limited.
- Smith, C., Selbie, D., Mercer, G., & Shepherd, M. (2020). Evaluation of the OVERSEER® pastoral block N model (v.6.3.1): 2. Setting up files & systems. Overseer Limited.
- Tavernet, J.-P., & Harper, J. (2022 a). Sensitivity analyses on nitrate loss at the farm level estimated by the Overseer science model. Overseer Limited. https://assets.ctfassets.net/bo1h2c9cbxaf/1k2maX4yQvUpTW8LXY3rBJ/e5a707917ef63c7a7b320062a8b13665/Sensitivity_report.pdf
- Tavernet, J.-P., & Harper, J. (2022 b). Uncertainty analysis – propagation of input climate data and soil uncertainties on nitrate-loss estimated by the Overseer science model. New Zealand: Overseer Limited. https://assets.ctfassets.net/bo1h2c9cbxaf/4HprUvSG1fiB7eeoRJgrxW/40a39b19ac30c3d49dcfdc818c62a436/Uncertainty_analysis_report.pdf