The Government response to the findings of the Overseer peer review report

Ministry for the Environment
Manatū Mō Te Taiao

Ministry for Primary Industries
Manatū Ahu Matua

New Zealand Government

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Message from the Ministers

There are three main causes of water quality degradation – excessive sediment, microbial contaminants and/or nutrients. For many New Zealand's rivers, the main nutrient challenge is excessive nitrogen in its various forms.

Diffuse nutrient discharges from farmland and their risk to freshwater are managed in a variety of ways, including through the use of the Overseer on-farm nutrient model. Overseer has helped farmers and regional councils gather data on inputs like fertiliser and livestock numbers, via an online, user-friendly interface. Using those data, it has sought to estimate the extent of nutrient 'loss' from farm systems.

Industry and environmental groups have, for some time, debated the application of Overseer's nutrient loss modelling to regional councils' planning and consenting functions.

In 2018 the Parliamentary Commissioner for the Environment recommended a review of Overseer be undertaken. An independent Scientific Advisory Panel was subsequently established by the Government to undertake this important work.

We thank the Scientific Advisory Panel for their careful review of the Overseer model. The Panel has identified a range of shortcomings in the modelling approach. The review will help us develop better tools for farmers and regulators to meet future Essential Freshwater requirements.

The Panel's findings require a response from Government. That is what this report provides. It is apparent that, at least in its current state, Overseer does not provide reliable results across the range of situations it is currently used for.

Overseer will be supported while the next generation of Overseer and additional tools are developed and made available to help manage nutrient losses from farms. We will also assist regional councils to continue with their freshwater plan-making, monitoring and compliance work.

We will now progress the next, solutions-oriented, phase of this programme to address the issues identified in the Panel's report. The attached document describes that work and the role that Overseer may play in the future.

Hon David Parker
Minister for the Environment

Hon Damien O'Connor
Minister of Agriculture

Executive summary

In late 2018 the Parliamentary Commissioner for the Environment (PCE) outlined steps that should be taken for the Overseer model to be used confidently in regulation, including recommending that a whole-model peer review of Overseer be undertaken by technical experts independent of those who developed the model[1]. That review was subsequently commissioned by the Ministry for Primary Industries (MPI) and the Ministry for the Environment (MfE). The Science Advisory Panel (the Panel) that undertook the review has now reported its findings. The Government thanks the Panel members for their hard work over the past year.

Overseer is a tool commonly used to inform our understanding of nutrient loss across agricultural landscapes and the effect of farm practices on those nutrient losses, at both farm and catchment scales. Although Overseer was conceived as a decision-support tool for agricultural producers (principally to inform fertiliser application decisions), it has evolved over the years to become a tool used by regulators to enable limits to be set for diffuse nitrogen discharges – compliance with which is required to be assessed using Overseer modelling.

Overseer does not model diffuse discharges of sediment or pathogens. Overseer's role in existing regulation is variable across the country but, where used, generally forms part of a wider suite of controls, including direct controls on practices and inputs and a requirement for farm planning, enabling farm-specific risks across all four main diffuse contaminants to be identified and addressed.

In 2020, the Government released the Essential Freshwater reforms. Important components of the reform package included the National Policy Statement for Freshwater Management (NPS-FM) 2020 and the Resource Management (National Environmental Standards for Freshwater) Regulations 2020 (NES-F). Neither of those instruments require the use of, or refer to, Overseer modelling. Nevertheless, it has been expected that Overseer would be used for implementation of some elements of those instruments.

In that context, the review is important. If Overseer is to be used to manage nutrients, we need to have a high level of confidence in its modelling estimates.

The Panel concluded that, in its current form, it would not have confidence that Overseer's estimates of nitrogen lost from farms are suitable for use as a stand-alone measure of total losses. The Panel concluded that, in its current form, it would not have confidence in Overseer's estimates of nitrogen lost from farms[2]. The Panel identified a general concern with the model structure as well as some specific areas of concern. Importantly though, the Panel did not assess the model for ease of use, its data files, nor its use as a social tool to encourage farmers to adopt farm management strategies that would successfully reduce a catchment's nutrient load.

The specific areas of concern include that Overseer:

- does not balance mass (that is, some nitrogen is not accounted for or is unexplained)

[1] Parliamentary Commissioner for the Environment, 2018. *Overseer and regulatory oversight: Models, uncertainty, and cleaning up our waterways*.

[2] In accordance with its terms of reference, the Panel did not consider Overseer's modelling of greenhouse gases.

- treats the soil as a single homogenous layer, limiting its ability to model soil hydrological flows and, therefore, drainage of the soil solution and nitrate leaching
- does not adequately capture overland flow; such flow can, in some landscapes, be a significant pathway for losses of non-nitrate forms of nitrogen. Overseer has focused more on leaching of nitrate-nitrogen
- uses a form of climate data averaged over 30 years rather than actual climate data, with the consequence that drainage and episodic weather events (eg, high rainfall events associated particularly with high nutrient loss risk periods) are not adequately represented.

The Government's response to the Panel's findings will be to put in place one or more of the following options:

(a) the creation of a *new risk index tool*, potentially using elements of Overseer (including the user interface); and

(b) development of a next generation *Overseer* to address the issues raised by the Review Panel and ensure that it is fit for purpose as a tool to use in appropriate regulatory settings; and/or

(c) greater use of *controls on practices and inputs* to manage nitrogen loss (including through amendment to the NES-F); and/or

(d) a completely new approach to understanding and managing diffuse nutrient loss risk. This might include, for example;

  (i) near *real-time monitoring* of water quality at the local scale

  (ii) a tool that provides detailed understanding of nutrient loss risk based on the *characteristics of land*

  (iii) a new nutrient loss model.

The options recognise that Overseer currently plays many roles and a wider suite of tools are likely necessary to adequately fulfil future needs.

The options also recognise that some issues of concern identified by the Panel may be able to be addressed. Some issues may be easier to address than others. For example, it would be possible to modify Overseer to use actual climate data rather than data averaged over 30 years. Similarly, in most catchments with a high nitrogen load, nitrate-nitrogen is the predominant nitrogen species. Hence the issues raised by the Panel that Overseer focuses on nitrate-nitrogen, while not accounting adequately for nitrogen lost by overland flows may not be material in those catchments and could be addressed by restricting the recommended use of Overseer to particular catchments or situations (that is, where overland flows are not a factor because of low slope and good drainage).

The Government has committed to continuing to support Overseer while the issues raised by the Review Report, and possible options to address those issues, are resolved. This will ensure continuity of access to Overseer, as required by some existing regional plans and resource consents. It will also preserve options for the continued use and development of Overseer (or elements of Overseer) as set out in (a) and (b) above, while considering further options (c) and (d).

Statistical testing (such as sensitivity and uncertainty analyses) of all future nutrient management tools will be considered.

In the immediate term, regional councils will continue to implement their plans and administer consents to manage fresh water at the farm level. Councils will use all available evidence and will need to be careful not to rely solely on Overseer modelling for their understanding of total nitrogen losses. This will be particularly important where nitrate-nitrogen is not the dominant form of nitrogen loss. Where existing plans provide for alternative modelling approaches or for control to be exercised using means not dependent on Overseer, those opportunities should be considered.

As regional councils continue their regional plan development consistent with their obligations under the NPS-FM 2020, they can continue to use Overseer (as necessary) as an input to catchment-level modelling subject to the due diligence checks as outlined in this report. Similarly, councils can proceed to develop plans on the basis that farm-level nutrient loss estimating and/or risk assessment tool(s) will be available for use for the implementation of those new plans as required by the end of 2024, to give effect to the NPS-FM.

The Government will be taking action over the coming months to ensure all users are well placed and can act with confidence. MfE will issue guidance material for regional councils on the appropriate use of Overseer in its current form.

More broadly, MfE is also developing best practice guidance for models used in environmental regulation. This will inform the approaches and tools developed and used in the longer term. Transparency will be an important feature. This means the underlying scientific principles, sources of data and equations used to build the models must be available for public review. Transparency is vital for users and regulators to have confidence in models used in regulation.

1 Introduction

This report sets out the Government's response to the whole-model review of Overseer (the Review Report). That Review Report should be read alongside this document.

The Review Report was prepared in response to the 2018 report of the Parliamentary Commissioner for the Environment (PCE) entitled *Overseer and regulatory oversight: Models, uncertainty and cleaning up our waterways.*[3] The PCE's report noted that the whole Overseer model, and many of its sub-models, had never been subjected to the rigour of independent peer review and highlighted that a "significant amount of information needed to confirm Overseer's use in a regulatory setting is lacking".

Accordingly, one of several recommendations made by the PCE was that an independent review of the model be completed. In response, the Government convened an expert Science Advisory Panel (the Panel) comprising local and international environmental modelling and science experts.[4]

The Panel has now completed its review and its report has been publicly released. The Review Report reached conclusions that may be of concern to many users of Overseer.

The purpose of this report is to set out how the Government intends to respond to the Review Report and address the concerns of Overseer users to ensure agricultural producers and councils have the tools needed to make sound land-use decisions and contribute to the effective management of freshwater.

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[3] Parliamentary Commissioner for the Environment. 2018. *Overseer and regulatory oversight: Models, uncertainty, and cleaning up our waterways*. Wellington: Parliamentary Commissioner for the Environment.

[4] The names and credentials of the Review Panel members are set out in appendix A.

2 About Overseer

Overseer is a computer software tool that models the nutrient flows onto and off farms and farm blocks. Overseer aims to provide a quantitative description of farm nutrient dynamics for a range of farm-system types. It models nitrogen, phosphorus, sulphur, potassium, calcium, sodium and magnesium, as well as greenhouse gas emissions. It has supported farm decision-making for many years. Overseer originated in the 1980s as a way to help farmers and their advisors to make decisions about nutrient management and fertiliser use, in particular. As the model has been developed over time, the uses to which it has been put have increased, as has the variety of users and functions within the modelling tool.[5]

Overseer consists of the modelling software itself (not all of which is publicly accessible for scrutiny by third parties) and an award-winning user interface that is regarded as easy to use. The wider Overseer 'ecosystem' also includes a large database of farm input data and modelling results allowing reporting of not just individual farm-nutrient management performance but collective performance of multiple farms at various scales. This is a valuable resource for nutrient management and for understanding nutrient-loss risk across the landscape.

The Overseer model has various 'sub-models' within the Overseer model that represent aspects of the nitrogen cycle within a farm system. These sub-models are built on a significant body of scientific research, and that base research remains valid.

2.1 How Overseer is used

The Overseer tool is used in many ways by different user groups. It is used by farmers and their advisors as a tool to guide farm planning and management. Since around 2005, however, Overseer has also been used by many regional councils to help in freshwater management and planning. Use in regulatory contexts has been growing as regional councils have sought more quantified control and accounting of diffuse agricultural discharges to fulfil their obligations under the National Policy Statements for Freshwater that existed in the 2011–2019 period.[6]

The Overseer model is managed by Overseer Ltd. The Overseer model intellectual property is jointly owned by the Ministry for Primary Industries, the Fertiliser Association of New Zealand and AgResearch (the Owners) and is exclusively licensed to Overseer Ltd. A full discussion of the ownership structure can be found in the PCE report.

2.2 Positive features of Overseer

Positive features of Overseer that increase usability for farmers and their advisors include:

- automatic use of datasets (for example, climate and soil data)
- the use of real production information, feed and fertiliser input data, and farmer-estimated crop yields. This removes the need for the model to predict information that users already know

[5] Retrieved from www.overseer.org.nz.

[6] A description of the most common regulatory and non-regulatory uses of the tool is provided in appendix B.

- an enabling user interface, providing a level of user comfort in interacting with Overseer that is more difficult in many other models of agricultural and/or biophysical processes.

2.3 Policy context for Overseer use in regulation

In 2020, the Government released the Essential Freshwater reforms. The reforms had three main objectives:

- to stop further degradation
- to make material improvement in the health of waterways within five years
- set Aotearoa New Zealand on a path to restore its fresh water within a generation.

Significant components of the reform included the National Policy Statement for Freshwater Management (NPS-FM) 2020 and the Resource Management (National Environmental Standards for Freshwater) Regulations 2020 (NES-F).

As discussed below, the implementation of both instruments requires a tool (or variety of tools) to be available to primary producers and regulators to assess the risk of nutrient (and other diffuse contaminant) loss associated with land use. Being able to reliably estimate nutrient losses from agricultural landscapes at both farm and catchment scales allows for a broad range of regulatory responses and is particularly helpful when seeking to manage down losses fairly and consistently at the catchment scale.

Despite that, the use of Overseer is not a mandatory requirement of either the NPS-FM or the NES-F. Regional councils and others are not constrained in the tools they may use to fulfil functions and responsibilities under these instruments. Regional councils and agricultural users and their advisors would, nonetheless, be expecting to use Overseer for implementation of some elements of those instruments.

The Review is important in that context. If Overseer is to be used to promote the Government's objectives for fresh water, insofar as they are affected by nutrients, the Government needs to have a high level of confidence in its modelling estimates.

3 Overseer whole-model review

3.1 How the Science Advisory Panel undertook its review

The Panel was convened virtually in late March 2020 and met online many times over the following 12 months. Panel members received documentation from AgResearch and Overseer Ltd (including material that was the owners' intellectual property and not in the public domain); engaged in discussions about the modelling information with staff from both organisations; and heard from users of the model, including representatives from Waikato Regional Council and Environment Canterbury.

The Panel's approach to the review represented international best practice for assessing model adequacy, which includes assessing model structure, data used in model development, model behaviour, model sensitivity and comparing model results with experimental data. Much of the Review Report focused on a comprehensive assessment of the structure of the Overseer model, to determine whether Overseer adequately simulates the main pathways and processes that affect nutrient loss from agricultural farming systems.

Although the Panel acknowledged that assessments of model adequacy may include an assessment of whether the model is in good agreement with observational and experimental data, it also noted that a model's underlying structure must be sound for such a comparison with experimental data, to be useful. Therefore, the Panel did not consider comparisons with such data as part of its review. The Panel preferred instead to focus on a detailed interrogation of the model structure, as noted above. It considered that "comparing a large agroecosystem model to measured observational or experimental data is a tremendous challenge, one not commonly attempted in literature". The reasons for this opinion are not repeated here but are clearly set out in section 4.2.5 and section 10.2.5 of the Review Report.

The Panel drew on mātauranga Māori,[7] assessing the extent to which Overseer can support kaitiaki to improve or sustain the mauri and mana of Papatūānuku (the Earth Mother), as well as modelling, agricultural sciences and nutrient dynamics.

Under its terms of reference, the Panel did not consider Overseer's modelling of greenhouse gases (see Kelliher et al (2015) and de Klein et al (2017) for reviews of Overseer's greenhouse gas components[8]).

The Panel did not assess the model for ease of use, its data files nor its use as a social tool to encourage farmers to adopt farm management strategies that would successfully reduce a catchment's nutrient load.

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7 Traditional concepts of knowledge and knowledge systems

8 Kelliher F, Rollo M, Vibart R. 2015. Desk-top review of GHG components of Overseer: Draft report prepared for the New Zealand Agricultural Greenhouse Gas Research Centre. AgResearch report RE500/2015/081. Hamilton: AgResearch. De Klein C, van der Weerden T, Kelliher F, Wheeler D, Rollo N. 2017. *Initial review of the suitability of Overseer Nutrient Budgets Model for farm-scale greenhouse gas reporting: Final report for the Ministry for Primary Industries and the Biological Emissions Reference Group*. AgResearch report RE450/2017/022. Hamilton: AgResearch.

3.2 Review findings

The findings of the Panel are summarised below.

Overseer's structure and data

The Panel found that the use of average climate data, homogeneous soil profiles and the omission of ammoniacal nitrogen and soil organic matter dynamics within Overseer meant its predictions do not account for potentially significant components of nutrient losses, at least in some catchments and for some land uses. In addition, it found that Overseer does not, and was never intended to, model episodic events, such as intermittent heavy rain or periods of drought. The Panel considered this to be a significant weakness as episodic events can be critical drivers of nutrient losses on some properties, and farm plans to manage nutrient loss should factor such events into mitigation strategies. The Panel was also concerned that Overseer does not balance mass[9] and it inadequately accommodates deep-rooting plants.

Relative and absolute nitrate-loss estimates

The Panel noted that a common belief among users has been that using Overseer's modelled outputs to assess change or compare scenarios on the same property (that is, using it in a relative sense) means absolute accuracy is not required. It advised, however, that Overseer is unlikely to be a reliable tool for predicting either relative or absolute loss estimates. The reasons given are found throughout its report and summarised in the executive summary of the Review Report (page 7).

Mātauranga Māori and Te Tiriti o Waitangi

The Panel considered mātauranga Māori and Te Tiriti o Waitangi (the Treaty of Waitangi), and made two important points.

First, Māori have a definitive relationship with the natural world, determined through whakapapa. This remains crucial to environmental management, including of soil and water resources, especially in production systems. This relationship forms the foundation of mātauranga, which, in turn, informs cultural decision systems. Mātauranga is primarily applied through kaitiaki responsibilities so that resource sustainability is both understood and achieved.

Second, Te Tiriti o Waitangi and its related principles have a role in land and water decision-support tools. Both mātauranga Māori and the principles of Te Tiriti o Waitangi must be given effect in regulatory and decision-support tools for them to be fit for purpose for Māori.

The Panel then considered the Overseer tool itself in light of its above conclusions. It found that, throughout the development of the Overseer model, there had been no engagement with Māori. Neither the relationship Māori have with the natural world nor the role of Te Tiriti

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[9] Overseer balances the movement of nutrients between blocks, but this is not a guarantee that mass balance is preserved for actual nutrient dynamics in crops and pastures. Over the duration of a model run, the amount of nitrogen initially in the system plus the amount added may not equal the amount at the end of the run plus the amount removed. The model uses the terms 'balancing error' and 'nitrogen deficit' to correct the numerical inequality in the model, but the Panel considered that this does not restore mass balance in the formal sense of the process.

o Waitangi and its related principles have been included within Overseer or contributed to its development. The Panel noted that Overseer Ltd has begun engaging with Māori more recently, but for a model to be used in regulation in Aotearoa New Zealand, developers must engage with and learn from Māori from the beginning, to ensure the model reflects te ao Māori (the Māori worldview), incorporates mātauranga and is useful to Māori land users.

3.3 Panel's conclusions

The Panel summarised its core concerns with Overseer are that it:

- is a steady state model attempting to simulate a dynamic, continually varying system
- uses monthly time-steps
- uses average climate data and, therefore, cannot model episodic events or capture response to climate variation
- does not balance mass
- does not account for variation in water and nutrient distribution in the soil profile
- does not adequately accommodate deep-rooting plants
- focuses on nitrate and omits ammoniacal nitrogen and organic matter dynamics
- lacks consideration of surface water and nutrient transport, as well as critical landscape factors.

Because of these concerns, the Panel did not have confidence that Overseer's modelled outputs can inform whether changes in farm management reduce or increase the losses of nutrients from the wide variety of property types and land uses across the country, or what the magnitude or error of these losses might be. The Panel considered that:

> Overseer's structure is not adequate to provide more than a coarse understanding of a farm's nutrient losses (except for surface flows since these are not included in the model). It also cannot reliably estimate how changes in farm management would affect those losses.

As set out in appendix B, there is widespread use of Overseer in Aotearoa New Zealand. Investment in the use and development of the Overseer model by different parties over recent years has been substantial. Many stakeholders will consider that the various roles Overseer plays are important to Aotearoa New Zealand's social, cultural, economic and environmental wellbeing. Additionally, regional councils, research entities and others managing freshwater have a clear need for tools to help them understand the scale and movement of nutrients across agricultural landscapes if the Government is to achieve its aspirations for fresh water. For those reasons, the Panel's findings raise serious concerns.

4 The Government's response

The Review Report has potential implications for:

(a) the immediate ongoing implementation of regional councils' planning and regulatory functions under the Resource Management Act 1991

(b) the design and development of new regional planning provisions, to give effect to the NPS-FM 2020 and to be notified by 2024

(c) the longer-term needs of all Overseer users

The following section sets out the Government's response to (a) to (c) above.

4.1 Ongoing implementation of planning and regulatory functions

When considering the immediate issues, it is important to note that the Government has committed to support Overseer (subject to regular reviews of progress) to ensure that the model remains available for use as required by existing plans and consents (and to preserve options for model redevelopment as discussed further below).

There is an important distinction between the use of Overseer to model nitrate leaching and the use of Overseer to model loss of all species of nitrogen. Although the Review Report expresses a lack of confidence of Overseer's nitrogen modelling generally, many of its concerns are based on the model's focus on nitrate-nitrogen and inadequate representation of overland flows and drainage. This suggests that where the dominant form of nitrogen loss is not nitrate leaching, councils will need to use all available information and be careful not to rely solely on Overseer modelling for their understanding of total nitrogen losses.

Existing resource consents and applications yet to be made

Overseer is embedded in the daily work of many regional councils and resource users (particularly resource consent holders in catchments subject to nitrogen-leaching limits). In some cases, operative regional plan rules already require resource consents with Overseer 'N-loss' numeric limits for various rural land uses and associated diffuse nutrient discharges. Many consents have already been granted. Others are being applied for (or soon will be) by applicants. Those existing resource consents must be administered and new applications processed by councils as the consent authority. The Review Report does not change that.

It is important that regional councils continue to implement their plans, administer existing consents and process new consents in a manner that promotes the objectives and policies of those plans despite the issues raised by the Panel's report. The Government is aware that there are challenges in doing so and will work with the most affected regional councils to develop guidance material. Some material will be generically applicable to all regional councils that use Overseer in a regulatory context but some will be bespoke to specific councils, recognising the particular characteristics and requirements of individual regional plans.

While the detail of that guidance is to be determined in collaboration with regional councils, it will focus on the following general principles.

- Where opportunities exist to use additional data, alternative modelling or for control to be exercised using means not dependent on Overseer, those opportunities should be considered in addition to, or as an alternative to, Overseer modelling. This will be particularly important where landscape factors and other evidence suggests that nitrate-nitrogen is not the dominant species of nitrogen loss at the farm and/or catchment scale.
- As discussed in section 5, it is likely that Overseer could be redeveloped to improve the confidence we can have in its nitrate loss modelling; accordingly, consents issued should provide for the future potential use of a redeveloped model to the extent possible given the scope of existing plan provisions.
- In the period before any redevelopment of Overseer, councils are legally obliged to implement the provisions of their regional plans and resource consents. These statutory documents may not allow alternative approaches to be adopted. However, to the extent that existing plans and consents allow:
    - Councils should use all available tools/data and be cautious in placing too much emphasis on Overseer modelling as a means of exercising control through the imposition of consent conditions or in any compliance and enforcement context. Conditions placed on any new consents should allow for compliance to be demonstrated using 'multiple lines of evidence'
    - compliance to be demonstrated with existing plans and consent conditions using a 'best information available' approach should be considered in addition to Overseer modelling where plans and consents allow for such an approach. In that regard, the body of science on which Overseer is, in part, based will be relevant to consider and apply as appropriate to the context[10]

These principles are considered to be consistent with treating Overseer modelled estimates as providing a coarse representation of nitrogen leaching only.

Administering existing resource consents after a new tool becomes available

When a new tool (or tools) becomes available (see section 5), consents may need to be updated to ensure those tools can be applied and consents can be complied with, monitored and enforced. While reviews of consent conditions under section 128 of the Resource Management Act 1991 are an option, a more efficient and effective mechanism may be required. This will be a matter that is considered as part of the resource management legislative reform programme.

Implementing the National Environmental Standards for Freshwater

The NES-F regulate, among other things, specific forms of agricultural intensification and the application of synthetic nitrogen fertiliser.

[10] Nitrogen risk factors are well researched. This includes, for example, the relationship between livestock urine patches (and hence stocking rates) and nitrogen leaching, or the relationship between nitrogen fertiliser use and potential nitrogen losses (if farm production remains constant). Metrics, such as purchased nitrogen surplus and nitrogen-use efficiency, will remain important and useful, particularly when used in conjunction with an understanding of changes in nitrogen-loss risk factors (such as stocking rates and fertiliser use).

The NES-F state that where a consent is required for agricultural intensification, consent will only be granted if the applicant can show that the activity will not result in an increase in:

- contaminant[11] loads in the catchment, compared with the loads as at the close of 2 September 2020
- concentrations of contaminants in fresh water or other receiving environments (including the coastal marine area and geothermal water), compared with the concentrations as at the close of 2 September 2020.

Similarly, where an applicant seeks consent to apply more than 190 kilograms of nitrogen per hectare per year (kg N/ha/yr) they need to show that the amount of nitrogen leaching to water would be no greater than would occur if the 190 kg N/ha/yr limit was met.

Although not specifically required by the NES-F, an Overseer report and nutrient budgets comparing the 'before and after' scenarios would generally have been expected to support applications for land-use intensification or for those exceeding the 190 kg N/ha/yr fertiliser limit.

Given the Review Report findings, the use of the Overseer model alone for this purpose will not provide sufficient certainty that the relevant requirements of the NES-F are satisfied. As discussed in the context of resource consents under regional plans, additional evidence based on accepted science will be needed to corroborate any Overseer modelling where used in association with applications made under the NES-F. Once Overseer has been redeveloped or an improved alternative tool is available, these should be used in preference to the current Overseer model. Further detail on how applicants might approach the provision of such evidence will be set out in specific advisory notes for regional councils provided by MfE.

4.2 Developing regional plans to meet the NPS-FM deadlines

Catchment modelling for 2024 regional plans and plan changes

To meet the 2024 deadline for developing new plans or modifying existing plans to give effect to the NPS-FM, most regional councils have started or completed catchment-modelling processes or will do so within the next 12 months. Some councils will have used or would be planning to use Overseer modelling as part of these processes. This may be to understand the sectoral source of contaminant loads and the cumulative effects in catchment loads of different farm-scale mitigation options.

The availability of alternatives to Overseer in catchment modelling (for example, APSIM)[12] is understood to be severely limited because of capacity and capability constraints, because the use of these models requires specialist expertise.

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[11] The Resource Management Act 1991 provides a broad definition of contaminants. In practice, however, the contaminants of focus in these regulations are nitrogen, phosphorus, sediment and *Escherichia coli* (as an indicator of microbial contamination).

[12] APSIM: the Agricultural Production Systems sIMulator; for more information, see www.apsim.info.

Continued use of Overseer to inform catchment modelling and to develop plans in the pre-2024 period will be necessary. This use is considered an appropriate interim approach because catchment modelling:

- involves a high level of uncertainty
- does not require the same level of granularity in relation to nutrient-loss estimates as is required for property-scale limit-setting or consenting purposes
- will not (necessarily) directly translate to regulated nitrogen-loss limits at the property scale.

Even so, when deciding whether or how to use Overseer to inform catchment modelling and to develop or amend plans before 2024, councils may need to consider the following:

(a) Whether there are other models or data platforms that can generate the required farm-level nitrogen loss information, as an alternative to or to strengthen Overseer simulations, in the timeframes in which it is required.

b) Whether Overseer estimates can be subjected to expert review and sense-testing using multiple lines of evidence (for example, augmented by other models and/or expert judgment) to build confidence in modelling outputs before they are used in catchment modelling.

c) Whether the level of uncertainty associated with Overseer model estimates is acceptably low given:

   (i) the drainage characteristics of the land and the dominant form of nitrogen in the catchment

   (ii) the end use of the catchment modelling results.

Availability of fit-for-purpose tool(s)

The Government is committed to having a reliable and practical tool or tools to ensure regional councils and resource users can effectively manage nutrient discharges as part of their new regional plans.

The Review Report is not a reason to delay progressing regional plan development so as to be ready for notification by the end of 2024. As noted elsewhere in this report, we aim to have fit-for-purpose tools for use within regional plan rules be available within 12 months.

4.3 Managing the risks of increasing nitrogen discharges

As councils reduce their emphasis on Overseer modelling for compliance and enforcement of plan provisions and resource consent conditions, the risk is some resource users may perceive an opportunity to increase farming intensity before a new tool is available to use (see section 5).

The advisory notes to be prepared by MfE and regional councils will outline how this risk should be managed. These notes will focus on enforcing other non-Overseer controls (such as conditions that limit inputs or address specific farm practices) either directly or through farm environment plans, as far as possible within existing plan provisions and consent conditions, and by clearly communicating that no resource user will benefit in the longer term from short-term increases in intensity.

The need to ‘measure’ and enforce any such increases in intensity will be a consideration in the design of the tool(s) (see section 5).

The Government will monitor this risk closely. If necessary, an amendment to the existing NES-F could be made along with amendments already planned. Such an amendment would target potential intensification of existing farming systems in catchments subject to Overseer-reliant rules and would ensure regional councils have broad scope to impose appropriate consent conditions, despite any limitations imposed by their existing plans. Any such change to the NES-F would benchmark affected farms to a date no later than the date on which this report is released.

5 The way forward: the next 12 months

In the immediate term, the Review Report has implications for the degree of reliance that can be placed on modelled estimates from Overseer in its current form, in the context of existing regulatory uses of the model. The Review Report means the Government needs to assess the current approach to managing nutrients, reassess what tools (or range of tools) are really needed, and investigate the options for meetings those needs.

Since regional councils began focusing on addressing diffuse discharges of nutrients (during the past 10–15 years), Overseer has been the only tool readily available to them to manage nitrogen-leaching risk in a quantified way. It has been used as a policy-making and policy-implementing tool and for property-scale and catchment-scale nutrient management. It has been used in catchments with severe nitrogen enrichment issues and in catchments where nitrogen issues are of lesser concern. It has been used, in some fashion, by most regional councils.

Yet the current and future needs of regional councils and other potential users vary greatly. This depends on, among other things, the extent that nitrogen discharges and, specifically, which forms of nitrogen pose most risk to freshwater outcomes, the existing concentrations and forms of nitrogen in receiving water bodies, and the nature of land uses in a catchment. It is clear a broader suite of management tools is desirable.

At the same time, the Government recognises that a tool(s) to allow for the regulation of quantified property-specific reductions in nutrient discharges remains important in catchments with major nutrient-related freshwater quality challenges. Similarly, models that can estimate nutrient-loss at the farm-scale will be important if we are to 'calibrate' new nutrient loss risk management tools (such as risk indices; see appendix C) and/or estimate the effect on catchment nutrient loads of other, more direct, forms of regulation (for example, input controls).

Accordingly, within the next 12 months, the Government will investigate, and put in place, one or more of the following options[13]

(a) the creation of a *new risk index* tool, potentially using elements of Overseer (including the user interface); and

(b) development of a next generation *Overseer* to address the issues raised by the Review Panel and to ensure that it is fit for purpose as a tool to use in appropriate regulatory settings; and/or

(c) greater use of *controls on practices and inputs* to manage nitrogen leaching (including through amendment to the NES-F); and/or

(d) a completely new approach to understanding and managing diffuse nutrient loss risk. This might include, for example:

  (i) near *real-time monitoring* of water quality at local scales

  (ii) a tool that provides detailed understanding of nutrient loss risk based on the *characteristics of land*

[13] The options referred to in (d) are likely to be longer-term possibilities than options that would be ready to implement within 12 months.

(iii) a new nutrient loss model.

For those reasons, the work streams set out in sections 5.2 to 5.4 are proposed.

5.1 Ongoing support for regional councils

As noted, the outcomes of the Review Report pose significant challenges for regional councils. The Government has prepared guidance for regional councils on using Overseer in its current form and covering the matters likely to be affected. These include consenting, regional plan-making, and compliance, monitoring and enforcement.

The Government will also continue to support the councils most directly affected. Further guidance material will be developed as needed.

5.2 Understanding our current and future needs

The Government proposes to use the next 12 months to further investigate the options identified above and develop the preferred option(s) so they are available by mid-2022.

This will begin with a needs analysis to ensure the Government has a clear and common understanding of the needs of all user groups. This work has already started.

Following this analysis, it is anticipated that, within a 12-month timeframe, there will be:

- a clear vision of Aotearoa New Zealand's nutrient-management tool needs at national, regional and local-user scales
- a tool(s) available for immediate use to replace and/or complement sole reliance on Overseer (being the risk index tool and, potentially, a redeveloped Overseer)
- a commitment to the development of additional tools over the longer term should those be necessary to meet our future needs.

Advice received during the review process regarding the Māori concepts and principles to be applied to this work will inform the work programme. This will include working with iwi and Māori on developing and implementing the programme.

The proposed work programme for the next 12 months will consist of three core workstreams, as described below and set out in figure 1.

All tools developed under this programme will be subject to sensitivity and uncertainty testing to the extent that is feasible and likely to yield reliable results.

At a broader level, an important parallel project is under way to better understand the expectations for, and uses of, models in environmental regulatory settings generally in Aotearoa New Zealand. MfE has commissioned guidance on this matter. That guidance is expected to be completed in late 2021.

5.3 Option (a): Nutrient risk assessment approach

MfE is leading the development of a risk assessment framework as an alternative and/or complementary tool to farm-scale nitrogen-loss modelling. Although described here as

an option, a commitment is in place to proceed with this tool development now, ahead of the needs analysis, to ensure its early availability.

The role this new tool will play in managing diffuse nutrient discharges is yet to be determined but it will be capable of fulfilling at least some of the roles currently performed by Overseer. MfE aim to have it available for use within 12 months.

Risk assessment and management approaches have been used as a means of managing a range of contaminants in both Aotearoa New Zealand and overseas. They have been developed based on accepted nutrient management science and have successfully reduced contaminant losses from farms in several jurisdictions. Examples are discussed in appendix C.

Although the most common risk indices used relate to phosphorus (see below), nitrogen risk indices have been developed where diffuse nitrogen discharges contribute to water quality deterioration. Risk indices have been developed to ensure that land management practice improvements are undertaken to reduce contaminant losses but, critically, these improvements would be effective at addressing the relevant issue in a specific receiving environment. In other words, to ensure that changes are targeted at the 'riskiest' practices in the 'riskiest' areas, so that the changes implemented are the most effective based on those risk profiles.

Contaminant risk assessment frameworks can take several forms. These include:

(a) a simple risk index that considers and 'scores' risks associated with either the:

  (i) choice of farm practices and inputs; and/or

  (ii) basic biophysical conditions within which the farm operates (soil type and rainfall) along with farm system type; or

(b) a more sophisticated assessment that, in addition to both the matters above, considers wider biophysical risk factors, for example, slope, aquifer characteristics and the sensitivity of the receiving environment.

The risk assessment can take the form of a tabulated scoring system or a more sophisticated approach using software that can integrate and weight an array of factors to produce an indexed risk rating.

A critical factor of the risk assessment approach is that, for the process to improve practices, it must be coupled with an implementation mechanism. The risk assessment process itself can provide useful information about a farm's levels of risk, but a means is needed of ensuring that actions are taken to reduce that risk to ensure environmental outcomes are met.

For example, risk score thresholds could be used as a trigger for activity status in regional plans (as Overseer leaching rates have been), or the risk-index approach could be embedded within resource consent conditions or mandatory farm environment plans to drive practice change or audit gradings.

One potential benefit of a risk assessment regulatory approach is it could be used to address risks associated with loss of a wide range of diffuse contaminants beyond nitrogen (phosphorus, sediment and *Escherichia coli*), although this would add complexity.

5.4 Option (b): Amending Overseer to address Panel concerns

As set out in section 5.2, the option of developing a next generation Overseer remains and a redevelopment project is being established. It would appear that at least some of the issues of concern identified by the Panel may be able to be addressed. Some of these may be easier to address than others, such as modifying Overseer to use actual climate data rather than 30-year averaged data. Similarly, the issues raised by Overseer focusing on nitrate-nitrogen and not accounting for overland flows could be addressed by restricting the recommended use of Overseer to particular situations (for example, where nitrate-nitrogen is the predominant nitrogen species and slope and drainage characteristics are not conducive to overland flows).

In most catchments with greatest nitrogen load, nitrate-nitrogen is the predominant nitrogen species. Nevertheless, non-nitrogen species can be important contributors to freshwater degradation in some catchments. Hence the use of even a redeveloped Overseer may need to be supplemented with additional tools.

Importantly, when Overseer has been evaluated against farm systems experiments, and when actual climate and drainage data are used to parameterise the model, relatively good agreement has been reached between Overseer's output and measured nitrate leaching losses. This suggests that if Overseer can be 'redeveloped' to use real climate data and to adequately model drainage, users could have greater confidence in its use for estimating *nitrate* leaching.

Modelling overland flow and the non-nitrate species of nitrogen is more difficult. A critical needs analysis will be undertaken with regional councils. This will seek to understand in what catchments overland flow is a significant contributor to declining water quality and, where it is a concern, whether ammoniacal and organic nitrogen losses can be addressed in ways similar to how phosphorus and sediment are dealt with now.

Therefore, a redeveloped Overseer could continue to have a role. As confirmed by the Review Report, however, a suite of tools will be required in addition to a redeveloped Overseer to efficiently and effectively address all of our nutrient management needs for the future.

The Government will work to support the development of a next generation Overseer so that it can fully investigate the opportunities and plan an appropriate path for redevelopment.

5.5 Option (c): Control of practices and inputs

Controls are in place already at both regional and national levels on certain practices and inputs that aim to manage the nutrient loss risk from farms. These include, for example, regional council rules controlling the discharge of collected effluent, cultivation, irrigation and earthworks. Similarly, the NES-F already controls the application of synthetic nitrogen fertiliser and intensive winter grazing, and national regulations control stock access to water bodies.

If maximum nitrogen leaching rates cannot be set because of an inability to reliably monitor compliance, then another option is to extend the practice and input control approach.

This approach has well-known advantages and disadvantages that will need to be weighed against the risks faced and the efficacy of other available options.

Practice and input controls can be at the farm scale (by way of freshwater farm plans and individual resource consents), the regional or catchment scale (through regional plan rules), or at the national scale (through the inclusion of additional standards in the existing NES-F).

As with the risk index tool, input and practice controls would best be calibrated using a model (such as APSIM) to help us understand the actual and potential effect of the controls on nutrient-loss at the property and catchment scales.

5.6 Option (d): New management tools

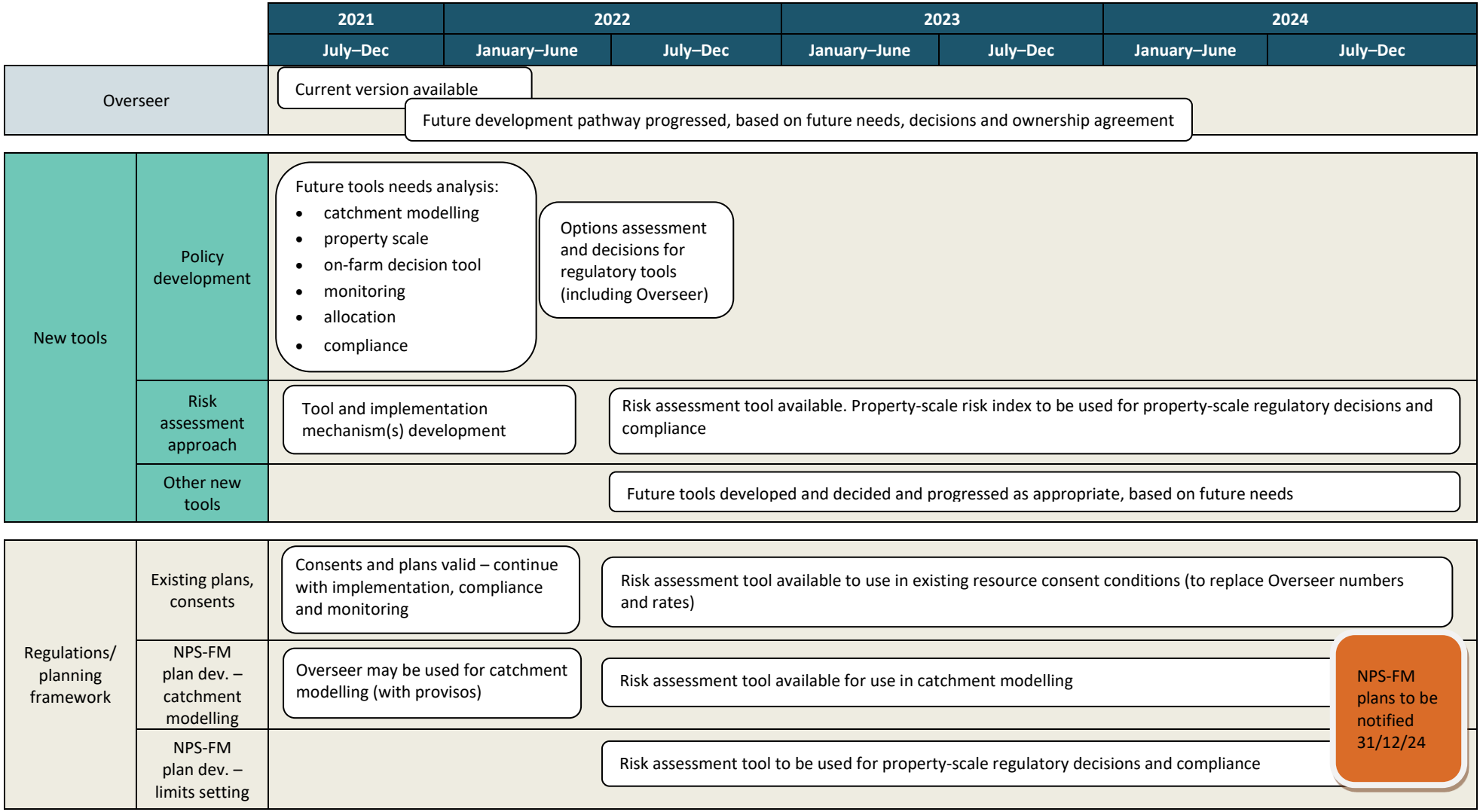
The Government fully expects that further needs analysis may well identify the need for additional, or perhaps alternative, tools for the effective and efficient management of nutrient loss risk. At this stage, those alternative tools have not been fully scoped. The Government will, however, be further investigating the feasibility of the following options, as a minimum.

(a) Near real-time monitoring of freshwater quality at high resolution (potentially farm) scale. This technology and investment could allow, for example, property-scale nitrogen loss limits to be imposed with compliance dependent on surface water monitoring rather than, or in additional to, below the root zone modelling.

(b) Landscape risk assessment. Nutrient loss risk is dependent on land use, climate and underlying physical characteristics of land. Understanding the vulnerability of land to nutrient loss (and the main transport pathways of that loss) allows controls to be tailored to maximum effect and action and investment to be prioritised.

(c) A new nutrient model. To enable the effective and equitable regulation of nitrogen loss reductions, a nutrient loss modelling tool that can perform the function that some regulators have sought from Overseer over the past 15 years may be identified by the needs assessment as important. If Overseer cannot be restructured to perform that task, a new model may need to be developed. This is a long-term and likely expensive option so will only be considered in detail if it is determined that other options cannot deliver the required level of risk management and control.

Figure 1: Future work timeline



Appendices

Appendix A: Science Advisory Panel

Dr Ian Johnson
Dr Johnson is a mathematician with experience in developing and writing biophysical computer simulation models incorporating environmental physics, plant, crop and pasture growth, soil hydrology, soil organic matter and nutrient dynamics, and animal growth and metabolism. Early in his career he was with the Biomathematics Department at the Grassland Research Institute in the United Kingdom and then the Department of Agronomy and Soil Science at the University of New England in Armidale, New South Wales. More recently, as Director of IMJ Consultants, he has developed models in collaboration with universities and industry bodies in Australia and Aotearoa New Zealand. He is widely published in the scientific literature, including as co-author of the textbook *Plant and Crop Modelling* (Thornley and Johnson, 1990, 2000).

Mr Dave Clark
Mr Clark is a dairy industry and research consultant. Between 1991 and 2013, he was Principal Scientist at the Dairying Research Corporation/Dexcel/DairyNZ. His research during that time looked at the intersection of farm economics and environmental impact and was supported by a philosophy that environmental protection and profitable dairy farming are not mutually exclusive. In 2009 he was awarded the New Zealand Grassland Trust – Ray Brougham Trophy for services to Aotearoa New Zealand farming systems. He carried out mainly hill country research when he worked at Grassland Division, Department of Scientific and Industrial Research in the early stage of his career.

Dr Brent Clothier
Principal Scientist with Plant & Food Research, Dr Clothier has extensive experience in soil science, especially with the measurement and modelling of water and solute movement in soil. He has published more than 300 peer-reviewed publications. He was elected a Fellow of the Royal Society Te Apārangi in 1994 and was the President of the New Zealand Society of Soil Science from 2008 to 2010. He is an Academician (Foreign) of the Chinese Academy of Engineering (Agriculture Division).

Dr Donna Giltrap
Research Priority Area Leader for Agricultural Greenhouse Gases Emissions and Mitigation at Manaaki Whenua – Landcare Research, Dr Giltrap is a modeller with a background in physics and mathematics. Her doctorate is in physics and she also holds a graduate diploma in applied statistics. She was part of the team that reviewed the nitrous oxide component of Overseer in 2018. She is a member of the New Zealand Soil Science Society.

Dr Clint Rissmann
Dr Rissmann is the Founder and Director of Land & Water Science Ltd. He is also a Senior Adjunct Fellow in the Waterways Centre for Freshwater Management – a partnership between the University of Canterbury and Lincoln University. He has more than 10 years' experience in earth systems science, specialising in water quality, biogeochemistry, greenhouse gases and systems thinking. He has co-authored several peer-reviewed publications researching soil and water quality in Aotearoa New Zealand. He is a leading proponent of the physiographic approach, which involves understanding water quality outcomes based on an integrated understanding of landscape properties.

Dr Nick Roskruge

Dr Roskruge is of Atiawa ki Taranaki and Ngāti Tama-ariki descent. He is Professor in Ethnobotany at Massey University and, since 2003, has been Chairperson of Tāhuri Whenua, which represents Māori interests in the horticulture sector. He is a member of the Māori Advisory Board for Resilience to Nature's Challenges – a National Science Challenge – and is also a member of the Hazardous Substances and New Organisms Committee of the Environmental Protection Authority (EPA). Previously he was Chair of Ngā Kaihautū Tikanga Taiao, the EPA's Māori advisory committee. He holds a doctorate in soil science with his doctoral thesis looking at Māori land development through traditional knowledge, and the soil and horticultural sciences. He has spent time in Peru and Chile, where he worked on crop genetics and indigenous systems projects. He received a Fullbright Scholarship in 2013, undertaken at Cornell University (USA).

Dr Peter Thorburn

Dr Thorburn is a Chief Research Scientist and Research Group Leader in the Commonwealth Science and Industrial Research Organisation (CSIRO) in Queensland, Australia. He is responsible for agricultural systems research and is internationally recognised for his expertise in crop systems modelling. He represents CSIRO on the Agricultural Production Systems sIMulator (APSIM) initiative, which owns the APSIM advanced farming systems model, and is co-lead for crop modelling in the international AgMIP program. He has extensive experience in scientific advisory groups, including as a member of groups on managing water quality in Great Barrier Reef catchments and reviewing or advising on Overseer in 2012 and between 2014 and 2017.

Dr Robin White

Dr White is Associate Professor of Integrated Beef Systems Management at Virginia Tech in the United States of America. She is a member of the American Dairy Science Association, an editor for the Farm Systems Analysis and Economics and Resources and Environment sections of the *Journal of Dairy Science*, and an Editorial Board member of the *Journal of Animal Science*. Her research focuses on leveraging data analysis and animal nutrition to enhance the sustainability of food production systems. She graduated from Washington State University as a Doctor of Philosophy in Animal Sciences.

Appendix B: Existing use of Overseer

Use of Overseer by regional councils

Overseer has been used to different degrees and in different contexts by regional councils around the country. Some councils have Overseer embedded (whether explicitly or indirectly) within their planning and consenting framework, while some use the tool as a non-regulatory method to encourage good farm management practices modelled to reduce nitrogen-leaching rates. Other councils sit along a spectrum between those two points and these various uses are outlined below. Overseer is used in some form by more than half of regional councils in Aotearoa New Zealand.

As a tool to help with catchment modelling

Overseer has been used to estimate nitrogen and phosphorus loads from various agricultural and horticultural land, including:

- as inputs to catchment accounting models, including to identify of key nutrient-loss source areas
- as a method of corroborating catchment accounting model outputs
- as a means of understanding the on-farm implications of modelled catchment loads, limits and reduction targets
- in conceptual modelling, to develop 'what-if' scenarios around land-use change (both intensification and de-intensification) and 'bundles' of options to mitigate environmental effects.

In plan making and regulation design

Overseer-derived nitrogen-leaching rates have been used by councils when developing plans and associated regulations to manage land-use intensification, including:

- in plans as trigger points for defining resource consent activity status (for example, farms modelled to be leaching more than a specified rate of nitrogen are required to obtain a resource consent rather than being a permitted activity)
- in plans as trigger points for the application of specific policy approaches upon consenting.

Limit setting (either in plans or resource consents)

The National Policy Statement for Freshwater Management 2020 (NPS-FM) (and its predecessors) requires regional councils to set values, objectives and limits for freshwater bodies in their region. Some councils have used Overseer as the means of setting limits and managing freshwater discharges to achieve objectives. This has been through:

- the setting of property-scale nitrogen-leaching limits as absolute rates, for example, a requirement that farms must not discharge more than 30 kilograms of nitrogen per hectare per year, as modelled using Overseer
- the setting of property-scale leaching limits as rates relative to a baseline leaching rate, for example, a farm must reduce its leaching rate over a period of five years by 10 per cent from the average annual leaching rate during a specified period
- as an extension on the above usage, the setting of property-scale leaching limits within a catchment-scale cap-and-trade system. In these instances, a total nitrogen load for a

catchment is set, with maximum leaching rates capped for individual properties. The caps can only be exceeded if nitrogen is purchased from another land user whose leaching rate is below the cap.

Consenting

Overseer has been used as a part of the resource consent processes by some councils as well as within plans as:

- a method approved for determining nitrogen losses
- the means of allocating nutrient losses to farms operating under a collective nutrient discharge allowance resource consent
- the means of demonstrating that an activity will not result in an increase in contaminant losses (specifically nitrogen) when seeking to intensify land use, which requires a resource consent under the Resource Management (National Environmental Standards for Freshwater) Regulations 2020.

Compliance

Overseer has been used in some regions to demonstrate compliance with resource consent conditions or permitted activity standards, such as the distribution of nitrogen loading across multiple users, demonstrating nitrogen reductions, or demonstrating that nitrogen discharges are not increasing beyond an approved baseline discharge limit.

Within farm environment plans

Farm environment plans (FEPs) will usually incorporate a range of management areas, such as soil health, nutrient management, riparian management, irrigation, biodiversity and effluent management. The nutrient management component will generally require the completion of a nutrient budget, and Overseer is the most common method to derive these and is compulsory under some programmes.

Freshwater farm plans (or FEPs with a freshwater component) will become mandatory in the future as part of the Essential Freshwater policy package.

Freshwater accounting

Overseer has been used by some councils as a method within their freshwater quality accounting systems, similar to its use in catchment modelling processes. This can include tracking land-use change and intensification levels over time against a baseline state and estimating further effects on nutrient loads and concentrations (such as under altered flow regimes caused by climate change).

Overseer as a non-regulatory decision-support tool

Overseer is widely used across the primary sector for various non-regulatory uses. The use of Overseer as an on-farm decision-support system continues to be its fundamental purpose. OverseerFM, the current version of the tool, is used on thousands of farms across Aotearoa New Zealand. This core function has extended beyond the farm gate, and the tool is now used in a variety of settings for a variety of purposes.

The main uses of Overseer beyond those in the regulatory context are summarised below. This is not an exhaustive list.

Some of these are related to the use of Overseer in the regulatory context, however, they are not explicitly described above and are therefore set out here.

Nutrient budgeting

The Overseer nutrient budget is the main output of the tool. It describes how nutrients flow on farm blocks or across the whole farm. A budget is broken down into nutrient added, removed and internal transfers.

The budget allows a farmer or grower to see where nutrients are being lost to the environment. Regulation has focused on Overseer's modelling of nitrogen lost through the root zone. Overseer, however, also models phosphorus, potassium, sulphur, calcium, magnesium and sodium. Various factors (farm-system type, receiving environment, soil properties and so on) will determine which nutrients are critical for a particular farm or block.

Greenhouse gas emissions recording and reporting

The Overseer model estimates methane, nitrous oxide and carbon dioxide emissions for a farm by their source. Estimated values for each gas are converted to kilograms of carbon dioxide equivalent per hectare per year so they can be compared with each other and other greenhouse gas reporting. Greenhouse gas estimates have been available in Overseer since 2008.

A carbon stock tool has also recently been added, which estimates the carbon sequestration potential of tree blocks on farm.

Benchmarking and aggregated reporting

OverseerFM (launched in 2019) allows for farm benchmarking and aggregated reporting. This is used by groups of users to assess their performance against other farms and can provide for group reporting. This is particularly useful where farms operate under a collective environmental management strategy or system.

Scenario testing and planning, investment decision support

Many farmers and growers use Overseer as a means of informing investment options on farm, using the scenario-testing functionality. This is particularly the case where Overseer has been used in a regulatory context and a fixed nitrate-loss number must be attained or a percentage reduction in modelled losses is required over time.

Overlaying financial information onto these options means farmers can assess different options to reduce their environmental footprint;– the best bang for their buck. These options can then also be assessed by financial institutions (see below).

Other uses

Due diligence, banks and other lending institutions

Banks and lending institutions use Overseer to assess the bankability of options on a farm within environmental limits, and as part of due diligence on assessing farm sales and purchases.

Overseer output reports are also used in the marketing and saleability of properties, particularly those with nitrogen limits imposed through regional regulations.

Some institutions may offer premium products to farmers able to demonstrate high levels of sustainability (for instance, reduced interest rates on borrowings). Sustainable finance is a rapidly growing trend across the globe, where financing is linked to sustainability targets agreed by the lender and borrower. If the borrower meets the targets, they receive a funding discount, but if their environmental indicators worsen, they may have cost increases imposed.

Use in research

Overseer has been used extensively in research in Aotearoa New Zealand to help in understanding nutrient flows and farm environmental outputs.

Nutrient management qualifications and certification

Overseer is used within several university undergraduate programmes. It is also a key component of Sustainable Nutrient Management in New Zealand courses run by Massey University. Completion of these courses is required to become a Certified Nutrient Management Advisor.

Component or contributor to other tools, models or systems

Overseer is used as a component of, or contributor to, other tools, models and systems. Where Overseer outputs or reports are a direct component of the tool, the implications will be more significant than if it is an indirect input.

Non-regulatory farm environment plan requirement

Processors and collective companies (such as irrigation schemes) often require their suppliers, members or shareholders to undertake farm environment planning (see above) or incentivise their use.

Appendix C: Examples of risk assessment approaches

Regional council engagement has highlighted the need for any risk-index system developed to be applicable across a range of land-use types, or for different indices to be designed to cater to the different risks associated with different land-use types (for example, a risk index for dairy and a different risk index for vegetable growing).

Two examples of nitrogen-risk indexing systems are provided below. These are provided for illustrative purposes only and do not reflect government policy. The first was developed by McDowell et al[14] for use in the United States of America. The second was developed by Fonterra as part of its Tiaki programme to help its shareholders manage nitrogen risks in the New Zealand context. It is therefore designed specifically for the New Zealand dairy sector.

Example 1: Nitrogen-indexing system

Nitrogen-indexing system (from McDowell et al, 2002)[15]

	Factors	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)
Part A Nitrogen *Transport* Characteristics	Texture	Clay	Clay loam to silty clay loam	Loam to silt loam	Loamy fine sand to coarse sandy loam	Sand
	Permeability	N/A	Infrequent irrigation on well-drained soils	Moderate irrigation on soils with slopes < 5%	Frequent irrigation on soils with slopes of 2% to 5%	Frequent irrigation on soils with slopes < 5%
	A score = texture rating x permeability rating					
Part B Nitrogen *Source* Characteristics	**Soil LRV** = Soil Test P (mg P kg^{-1}) x 0.2 x CP					
	Fertiliser rate = kg P ha^{-1}					
	Fertiliser application method and timing	**Very low (0.2)** Placed with planter or injected more than 2 inches deep	**Low (0.4)** Incorporated < 1 week after application	**Medium (0.6)** Incorporated > 1 week or not incorporated > 1 week following application May–Oct	**High (0.8)** Incorporated > 1 week or not incorporated following application Nov–Apr	**Very high 1** Surface-applied on frozen or snow-covered soil
	Fertiliser LRV = Fertiliser rate x application method and timing score					
	Manure application method and timing	**Very low (0.2)** Placed with planter or injected more than 2 inches deep	**Low (0.4)** Incorporated < 1 week after application	**Medium (0.6)** Incorporated > 1 week or not incorporated > 1 week following application May–Oct	**High (0.8)** Incorporated > 1 week or not incorporated following application Nov–Apr	**Very high 1** Surface-applied on frozen or snow-covered soil
	Manure LRV = Manure rate x application method and timing score					
	B score = sum of source characteristic ratings					
	N Index Rating = A score x B score					

[14] McDowell R, Sharpley A, Kleinman J. 2002. Integrating Phosphorus and Nitrogen Decision Management at Watershed Scales. *Journal of American Water Resources Association* 38, 2.

[15] Ibid.

Example 2: Nitrogen-risk scorecard

The Tiaki programme scorecard assesses risk across six farm practice areas that have been identified as the primary drivers of nitrogen loss from dairy farms. Each management practice starts from a position of zero points, with points being added under each key risk practice. Moderating practices can add or subtract points depending on the practice.

For example, in relation to wintering practices, break-feeding on fodder crops will add 40 risk points to the base score, while wintering cows off pasture (such as in a barn or on a wintering pad) will reduce the base score by 40 points. The scores for each practice area are then totalled. All scores less than 20 are considered very low risk, and all scores greater than 80 are considered high risk.

Management practice	Key risk practice	Moderating practices
Nitrogen (N) fertiliser application	Amount of applied N	Conversion efficiency
		Timing of application
		Feed budget use
		Application rate
Stock management	Peak stocking rate	Pasture eaten
		Replacement grazing
		Wintering practices (x 2)
Imported feed	Total N imported through feed	Ratio of N supplements to product
		Average N content of imported supplements
Irrigation	Irrigation type	Soil moisture monitoring
		Application methodology
Cropping and cultivation	Percentage of farm cultivated annually via minimum till	Season of harvest
	Percentage of farm cultivated annually via conventional method	N fertiliser application
Effluent management	Discharge method	Application depth
		Disposal area

A mock example of how the final scores are set on the risk scale is provided below.

	Risk ratings				
Farm management practices	Very low < 20	Low 20–39	Medium 40–59	High 60–79	Very high 80 <
Stock management			✓		
Nitrogen fertiliser				✓	
Imported feed		✓			
Cropping and cultivation		✓			
Irrigation			✓		

Nitrogen-risk indices in action: US Clean Water Act

In the United States of America, the federal Clean Water Act (CWA) established the basic structure for regulating discharges of pollutants into waterbodies and regulated water quality standards (across a range of indicators) for surface water. The key parts of the CWA came into effect in 1972. At the national level, the CWA is implemented by the Environmental Protection Agency.

The CWA made it unlawful to discharge any pollutant from a point source into navigable waters without a permit. States were also required to identify waterbodies that were not meeting water quality standards (for various outcome areas including recreation, ecosystem requirements, drinking water and so on) set by the CWA (known as 'impaired waters') and then implement programmes to improve water quality.

The main parameter for determining water quality limits under the CWA is the total maximum daily load (TMDL). This is the maximum loading rate of given pollutants that a receiving water can assimilate without resulting in water quality impairments. TMDLs are set at the watershed (catchment) scale and include both point and non-point contributions. The TMDL approach is now used across the United States of America. Where a water body is 'impaired', a TMDL must be set to improve water quality to meet the relevant quality standard for the particular use value.

Where non-point source pollution is identified as contributing to the exceedance of TMDLs for impaired watersheds, most states have adopted environmental risk-index approaches to improve land management practices. Risk indices have been developed at the national, state and county levels across a range of contaminants.

A risk index for managing nitrogen in the United States of America will (at a minimum) determine the risk profile of a particular farm based on environmental (soil and climate) factors (see the national Leaching Index, below). Farms are then required to implement best management practices (BMPs) based on environmental risk-factor rating and their farm-system type. More sophisticated indices incorporate management practices within the index itself, to determine the overall rating (see the case study: "Nitrogen risk scoring in Virginia's Muddy Creek", below).

The United States Department of Agriculture's Natural Resources Conservation Service (NRCS) develops conservation practice standards, which state-level conservation practice standards must comply with at a minimum. State conservation practices can be more stringent than those set at the national level.

The NRCS Nutrient Management Code 590 applies to "all fields where plant nutrients and soil amendments are applied" and specifically to nitrogen, phosphorus and potassium. It requires NRCS-approved nitrogen-risk assessments to be undertaken "for all fields where nutrient management is planned unless the state NRCS, in cooperation with state water quality control authorities, has determined specific conditions where nitrogen leaching *is not* a risk to water quality, including drinking water".

The nationally mandated risk assessment criteria for nitrogen are either the Leaching Index or the Nutrient Tracking Tool. The Leaching Index will provide a score for a field based on soil type (including whether subsurface (tile) drainage occurs) and climate. The score for the field will then determine the appropriate management practices.

Leaching Index Score	Potential Leaching	Technical Guidance
< 2	Low potential to contribute to soluble nutrient leaching below the root zone	None
> = 2 and < = 10	Moderate potential to contribute to soluble nutrient leaching below the root zone	Nutrient management (Code 590) should be planned
> 10	High potential to contribute to soluble nutrient leaching below the root zone	Nutrient management (Code 590) must be planned AND practices planned to trap soluble nutrients before field loss via surface or subsurface drainage

The Leaching Index is being replaced in some states by the Nutrient Tracking Tool. This is an online tool that assesses nutrient-loss risks based on an array of environmental and practice input data, at a highly granular level. The most effective BMPS (environmentally and economically) can then be assessed using the tool as part of farm planning processes. A risk score is provided in the form of estimated nutrient loss rate, with a plus–minus margin of error. See https://ntt.tiaer.tarleton.edu/welcomes/new?locale=en for more information.

CASE STUDY: NITROGEN RISK SCORING IN VIRGINIA'S MUDDY CREEK IMPROVES WATER QUALITY

The Muddy Creek watershed in Virginia was found to be impaired for nitrate-nitrogen in 1998 because part of the river is designated for public drinking water and drinking water standards (10 milligrams per litre) were being breached. The total maximum daily load (TMDL) for nitrate-nitrogen was determined in 2000. Sources at the sub-catchment level were identified and the main sources of nitrogen were failing septic tank systems, pipe losses and discharges from agriculture. Agriculture is the predominant land use in the catchment (61 per cent) and some of the highest production intensive dairy and poultry farming in the state of Virginia is located in the catchment.

Community consultation was undertaken to help determine which best management practices (BMPs) should be implemented at the watershed scale to achieve the TMDL. Total nitrogen losses were managed through BMPs even though the goal was to reduce surface water nitrate levels. The development of farm plans, nutrient management plans, assistance with individual BMP identification (based on a farm's risk assessment), and funding assistance (where applicable) is delivered on the ground by the local conservation district (in this case, the Shenandoah Valley Soil and Water Conservation District).

Virginia state uses the national Leaching Index for assessing nitrogen risk, except for animal concentration areas where stock is fed in a fixed location (such as feedlots). These practices are assessed using the Risk Assessment for Water Quality Impairment from Animal Concentration Areas. This is a more sophisticated index than the Leaching Index, because it incorporates farm-specific management and environmental risk factors (beyond soil type and climate).

BMP implementation began in the early 2000s. By 2003, the area of Muddy Creek used for drinking water no longer breached the drinking water standard, and the trend continued. In 2010, the stretch of river was removed from the list of impaired waters for nitrate-nitrogen impairment. The watershed remains impaired for aquatic life due to reduced dissolved oxygen levels.

Riparian buffer and stock exclusion fencing on Muddy Creek.
Image courtesy of Shenandoah Valley Soil and Water Conservation District