



Overseer Model Description

Report for Overseer Limited
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Executive Summary

OverseerFM is a cloud-based farm nutrient management tool designed to inform an understanding of New Zealand farm nutrient cycles including potential losses at the farm boundary. Using Overseer to model potential changes to the farm system enables users to consider estimates of resultant changes to the nutrient cycle. This information can be used to enhance decisions focused on productivity and environmental risk. This document outlines the conceptual framework of OverseerFM, its underlying science model (Overseer), and guidance for its effective use, building on publicly available information.

Originally developed in the 1980s as a fertiliser and lime decision support tool, Overseer evolved to serve interests in farm scale nutrient modelling and greenhouse gas (GHG) losses. In 2016, Overseer Limited, a not-for-profit company, was established to manage intellectual property, support users, and drive ongoing development. Launched in 2018, OverseerFM integrates New Zealand-specific agricultural science to model nutrient cycling and GHG emissions, tailored to individual farm systems. This enables farmers to explore trade-offs between productivity and environmental stewardship.

Overseer Limited offers three products – OverseerFM, OverseerEd, and OverseerSci – each leveraging the same science model and soil/climate databases but with user interfaces customized to the distinct requirements of these specific user groups.

The Overseer science model, at the heart of all three software products, is grounded in empirical data, incorporating key factors such as urine patch dynamics and soil interactions to ensure estimated nutrient flows align with real-world farm systems. Its pragmatic design relies on readily available farm data and assumes a steady-state farm system, delivering actionable insights without requiring complex inputs. By integrating national soil, climate and topographic slope datasets with farm-specific information, OverseerFM models hydrology, soil effects, animal metabolism, effluent management, and crop/pasture growth to estimate nutrient budgets and GHG emissions.

OverseerFM empowers farmers to optimise nutrient efficiency, reduce environmental risks, and meet regulatory requirements, striking a balance between practical usability and scientific rigor.

1 Document purpose

This document outlines the key use cases that OverseerFM and its underlying science model (Overseer) were developed for. It provides a concise overview of the history and structure of Overseer and OverseerFM, followed by a detailed explanation of the science model’s purpose, design principles, theoretical foundations, technical scope, and usage guidelines. Additionally, it contextualizes related publicly available information (see Table 1).

Portions of this document are drawn from existing sources, including the “Introduction Technical Manual Chapter” by Wheeler (2018).

Table 1: Summary of existing Overseer model documentation.

Content Type	Purpose	Target Audience	URL
Knowledge Base Articles	Collection of helpdesk articles to describe the model use cases and how to use the software. These articles are also retrievable via the Overseer Ai Helpbot within OverseerFM.	End users of the OverseerFM software	Overseer Knowledge base
Model Flow Diagram	High-level visual description of the model inputs, interconnected sub-models, and model-predicted outputs.	End users, scientists	Science Model Diagram
Technical Manual Chapters (TMCs)	Each chapter has a detailed description of the science principles and equations for each of the sub-models.	Scientists	Available upon request
The Overseer Model Code and its documentation	Actual implementation of the Overseer science model.	Scientists, developers	N/A

2 Overseer model overview

2.1 History

2.1.1 Origins and Early Development

Overseer's roots trace back to New Zealand's efforts in the late 1980s to enhance fertiliser recommendations. The Computerised Fertiliser Advisory Service (CFAS) pioneered data-driven advice by compiling experimental results and local knowledge. By the early 1990s, extensive databases of phosphorus (P), potassium (K), and sulphur (S) fertiliser trials were established, laying the groundwork for future models.

In 1995, the first major model, Outlook, was launched, initially focusing on P, K, and S recommendations before expanding to lime. Outlook introduced an econometric tool that looked at the economic trade-off of pasture growth in response to P added, relative to costs, marking a significant step toward integrated nutrient management.

2.1.2 Shift to Environmental Focus

The 1991 New Zealand Resource Management Act heightened environmental awareness, prompting a shift in model development. In 1999, Overseer 2 was released, integrating nutrient budgets with environmental indicators, such as nitrogen loss (N-loss) and the impact of the nitrogen cycle on pH and lime requirements. The name changed from Outlook to Overseer to avoid confusion with Microsoft's emerging email program. Overseer 3, released in 2000, was the final version to include econometric modelling, with subsequent releases (e.g., Overseer 4) prioritizing environmental features like GHG emissions tracking, together with phasing out public econometric tools.

By 2004, Overseer 5 had evolved into a comprehensive farm-scale model, accounting for primary and secondary macronutrients, GHG emissions, and effluent management. Its widespread adoption facilitated Overseer's role in regulatory frameworks, providing a powerful alternative to input controls, for example, on N fertiliser use or stocking rates.

2.1.3 Further Developments and Innovations

- **2008–2012:** Significant upgrades, including monthly stock calculators, wetland modules, and a full web-browser-based version in 2012 (Overseer 6), which integrated all block types and improved scientific accuracy.
- **2009:** A formal ownership agreement between AgResearch, FertResearch, and the Ministry for Primary Industries (MPI) ensured sustained investment and robust governance.

- **2016:** Overseer Limited was established as a not-for-profit company to manage intellectual property, support users, and drive development, focusing on modernizing the user interface and transitioning to a cloud-based platform.
- **2018:** OverseerFM debuted as a user-friendly, subscription-based cloud platform for farm nutrient management, facilitating ongoing model improvements and community support.
- **2021:** A comprehensive government review led to recommendations for improving model transparency and scientific robustness (Science Advisory Panel, 2021).
- **2023:** Significant updates enhanced the model's predictive capabilities and expanded its applicability to a broader range of farming systems (MPI, 2023).

2.1.4 Overseer Today

OverseerFM is now a cornerstone of nutrient budgeting and environmental risk assessment in New Zealand agriculture. It empowers farmers and decision-makers with data-driven insights for sustainable farm management. Overseer Limited continues to support its user base, regularly updating the model and interface while maintaining strong ties with the agricultural sector, regional and central governments, and the scientific community.

For more details on OverseerFM's history, including specific releases and updates, refer to the [Overseer release notifications](#).

2.2 OverseerFM: A Cloud-Based Tool for Sustainable Farm Management

As of 2025, OverseerFM is a cloud-based platform designed to empower decision-makers in agriculture by providing insights into nutrient management and GHG emissions. Its primary aim is to provide a farm-scale analysis of how farm management practices influence nutrient cycles, including long-term annual average losses. OverseerFM is accessible at [this link](#), with comprehensive scientific, technical, and support resources developed for users are available in the [Overseer Knowledge Base](#).

2.2.1 How OverseerFM works

Users input real-world data about their entire farm system, enabling OverseerFM to generate a detailed nutrient budget (see Figure 1). For the purposes of the model, a farm is defined as its surface area to its physical boundaries, the base of the root-zone, at 60cm or 150cm dependent on block type, and to two metres above the surface. The underlying Overseer model simulates nutrient flows and losses based on factors such as management practices, weather, soil, and slope characteristics across different farm areas. This reflects real-world

nutrient dynamics, providing actionable insights. The platform tracks key nutrients – nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), and sodium (Na) – and reports on GHG emissions, including methane (CH₄), nitrous oxide (N₂O), and carbon dioxide (CO₂). CO₂ reporting accounts for upstream emissions (e.g., manufacturing and transportation) embedded in materials and energy used on-farm. Losses are categorized by transfers to products, leaching below the root zone, air, and animal-related processes (e.g., effluent or supplements).



Figure 1: Schematic demonstrating the basic flow of nutrients throughout the Overseer model at the farm block-scale, including management actions (e.g., dates of interventions, crop types, animal types) that ultimately impact the available nutrients.

2.2.2 OverseerFM product structure

OverseerFM is a sophisticated software solution comprising (see Figure 2):

- **Frontend:** A user-friendly web-based interface for data input and results visualization.
- **Backend:** The core model that performs the calculations for the nutrient budget, with data integration via both XML exchanges and API interfaces.
- **Databases:** Internal and external data sources that support the model's computations.

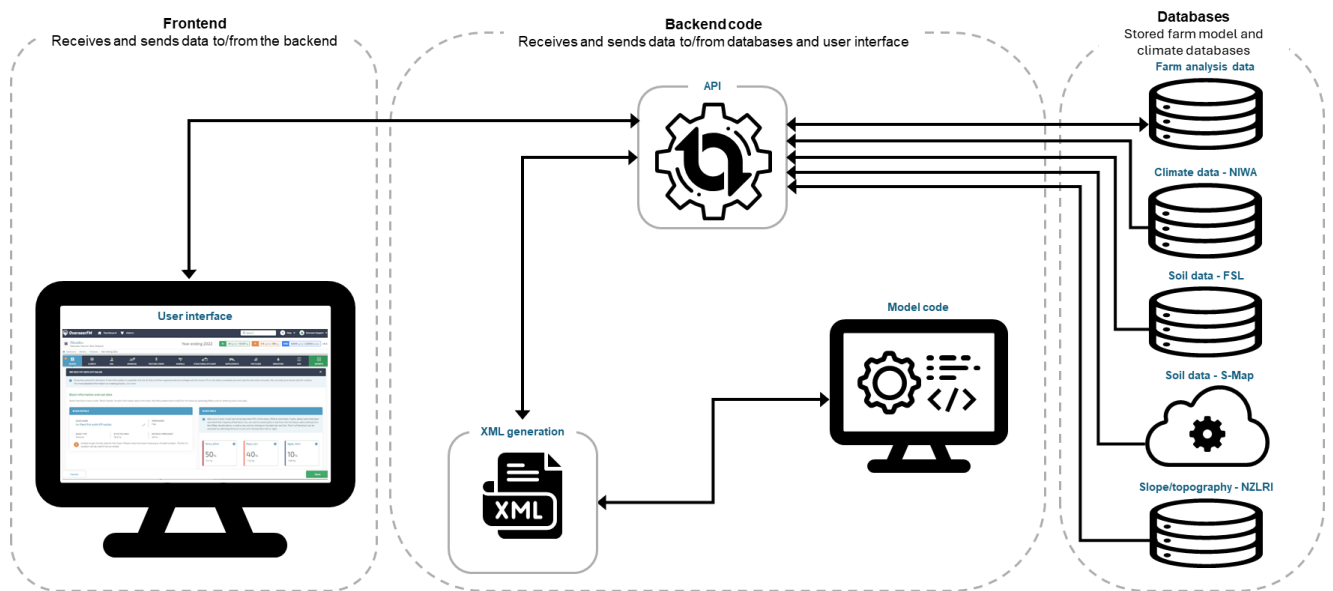


Figure 2: Schematic overview of the Overseer model-data framework, showing how the frontend, backend, and databases are connected and pass information.

2.2.3 Additional Overseer products

While OverseerFM is the primary focus, Overseer Limited offers two complementary platforms:

- **OverseerEd:** A learning platform used in university courses to help students understand farm nutrient budgeting, amongst other things, and gain familiarity with OverseerFM.
- **OverseerSci:** A specialized tool for advanced users, such as scientists and rural professionals, to explore innovative applications of the model, including calibration and validation using field trial data, or to collaborate with Overseer Limited on model enhancements.

Despite having different frontends tailored to each user group, all three products – OverseerFM, OverseerEd, and OverseerSci – share the same model code and database infrastructure, ensuring consistent calculations across platforms (see Figure 2). For more details, contact helpdesk@overseer.org.nz for OverseerFM and OverseerEd, or science@overseer.org.nz for OverseerSci.

2.3 Overseer model

2.3.1 Purpose and design criteria

The Overseer science model (often called the “Overseer engine” or “Model code”, subsequently referred to as “Overseer”) is the core of Overseer Limited’s products. Overseer’s main purpose is to help users understand how nutrients flow into, within, and out of farming systems and how these movements change with different management strategies. This information is designed to evaluate how effectively a farm system is using and retaining nutrients by identifying areas where high losses through leaching, run-off, or GHG emissions may signal inefficiencies or unsuitable land use.

2.3.2 Design principles

Overseer is designed to be user-friendly for the agricultural sector, using straightforward and auditable farm data to analyse existing farm systems. However, it requires the expertise of a rural professional or experienced farmer to ensure the farm is modelled accurately.

Overseer was initially built on two key design principles: (i) users only require readily available farm information, such as production data, and (ii) the farm system is assumed to be in a “steady-state”. To further minimise data and modelling requirements, Overseer also assumes some specific Good Management Practices (GMPs). Overseer’s calculations are made for individual farms by factoring in site-specific soil and climate conditions, and farm-specific management practices. Additionally, the original designers emphasized that a lack of data to “accurately” model a phenomenon shouldn’t prevent its inclusion in Overseer.

These key design principles shape how Overseer fulfils its main purpose and highlight areas where its use and outputs require careful consideration. The following sections explain these design choices in more detail, outlining their impact on Overseer’s structure, input requirements, and interpretation of outputs.

2.3.2.1 Design principle 1: Modelling with available farm data

First and foremost, Overseer is designed to be accessible and usable by industry. To achieve this, Overseer aims to provide meaningful insights without requiring extensive scientific farm data like that required by research-grade mechanistic models such as APSIM. A traditional modelling approach would use a detailed description of farm conditions to estimate what production is possible. In contrast, Overseer begins with what would typically or what could be produced by the farm – actual milk, meat, or crop yield is often used as representative – and, combined with farm management data and site-specific information, analyses nutrient flows and losses. Rather than forecasting what a farm might produce based on inputs like fertiliser use, rainfall, or soil type, Overseer uses specified production outcomes to work backwards. It estimates the amount of pasture growth (in addition to

specified crop yield) required to reach that production level, then calculates the associated metabolisable energy (livestock) and nutrient demands. Where available, complementary site information (e.g., soil, climate, and topographic slope data) is automatically derived from national databases for each farm management block.

From there, the model looks at the nutrients that were added to the system - including through fertiliser, effluent, or imported feed - and assesses whether that supply meets the farm's needs. The modelling includes the important contribution of clover in many New Zealand pastoral farm systems. Where white clover is selected as part of a pasture type, it performs an important role in the estimation of N fixation, some pasture nutrient concentrations, and pasture yield distribution through the year. If there is a deficit, the model assumes that nutrients were mined from soil reserves, which may not be sustainable over time. If there's an excess, the model calculates how much of that surplus may be lost to the environment (e.g., via leaching or runoff), highlighting potential environmental risks.

While not mechanistic in its structure, Overseer applies mass balance logic at the whole-system level; inputs, outputs, and changes in storage are accounted for in a way that aligns with known production and nutrient behaviour. Overseer does not simulate the process of mobilizing nutrients from reserves. Rather, it reports a deficit that must be filled to maintain the reported production and implicitly assumes that this deficit comes from soil reserves. This approach reflects a deliberate trade-off between precision and usability, supporting practical insights using typical farm data. This method allows Overseer to use simple, readily available farm data – like what was produced and how the farm was managed – to estimate the invisible flows of nutrients in the system. It offers a practical way to understand how management decisions affect nutrient efficiency, soil health, and environmental outcomes.

Minimising the data required from users makes the model more technically accessible and allows for a user-friendly interface tailored to non-modelling experts, such as rural professionals and tech-savvy farmers. However, this approach also restricts what can be calculated and sets a requirement for future Overseer updates: they must preserve the need to only require auditable, readily available farm system information.

Lastly, the approach of using minimal information from the user and a “back-calculation” method makes it increasingly important that the information provided represents a realistic (or at least chemically and biologically feasible) farming system. While there is some user-guidance within OverseerFM when unrealistic information or strategies are provided, Overseer can still generate outputs based on unrealistic information and thus reflect impossible scenarios (e.g., high pasture growth without fertiliser). Additionally, because Overseer “back-calculates” some aspects of the farm (e.g., pasture growth), it can be

challenging to align these estimates with those from other complementary tools that use “forward calculation” methods (e.g., input-based pasture growth models). To address this challenge, the Feasibility report in OverseerFM was developed to enable users to benchmark their modelled pasture blocks against blocks with similar physical characteristics.

To make this modelling approach feasible and applicable, two key assumptions are made about the farming system: that it is in a steady-state and governed by Good Management Practices (GMPs). The implications of these two assumptions are each significant in their own right and therefore are covered in subsequent sections (see [sections 2.3.2.2](#) and [2.3.2.3](#), respectively).

2.3.2.2 Design principle 2: Steady-state

Steady-state refers to a system that isn't fully in equilibrium but changes so slowly that it can be treated as if it is. A steady-state model assumes that input factors are balanced, so that the processes being modelled aren't changing significantly over the time scale being modelled. In Overseer, this means the farm system and management approach are assumed to change very little from year-to-year, and likewise the nutrient flows.

Using the steady-state assumption, many complex phenomena and nutrient processes can be represented with parameters (numerical constants), rather than comprehensive model equations. This approach enables a much simpler mathematical representation of the farm system, reducing data and computational requirements – both of which are critical limitations when modelling complex systems. Additionally, many of these parameters can be empirically derived, allowing for the modelling of complex farm systems in a way that minimises divergence (i.e., producing predictions or outputs that don't align with real world measurements).

Overseer is, however, only applicable when these parameters are relevant to the farm system – specifically, when the farm is assumed to be operating under steady-state conditions. Overseer can, therefore, be used to support strategic planning when using averaged climate data and actual farm data. So long as the farm system being described is not highly dynamic (i.e., year(s) of unusual seasonal conditions) or changing/transitioning (i.e., undergoing significant management or land use changes) then actual production and management can and should be used as proxies for typical. If a farm description from a year of unusual seasonal conditions or during a mid-land use change is provided to Overseer, there is a risk that the model may either fail to calculate results (i.e., return a model error) or produce results with high uncertainty – an important consideration for users.

That said, Overseer can be used to compare different land use scenarios for a given farm (e.g., beef and sheep vs dairy). Here, both farm descriptions need to be realistic and it must

be understood that what is being compared are steady-state scenarios (i.e., the described farm has been established for many years and changes minimally year-to-year). Overseer cannot be used to assess nutrient flows for years where a farm is transitioning from one land use or management scenario to another (e.g., in the early years of a conversion from forestry to dairy). But can be used to model the “steady state” farm system at the end of that transition process – e.g. year 10 of a conversion from forestry to dairy can be modelled, but not years 1-9.

2.3.2.3 Design Principle 3: Assumed GMPs

Overseer assumes some specific GMPs are followed, as not all processes can be fully modelled, and poor management is hard to quantify. Deviating from GMPs generally increases environmental losses.

The specific GMP assumptions include:

- **Fertiliser and effluent application:** Applied evenly across a block at the specified rate and time, therefore avoiding large discharges due to poor management.
 - Effluent follows DairyNZ guidelines (e.g., DairyNZ, 2012).
 - Fertiliser adheres to Fertmark and Spreadmark codes of practice (New Zealand Fertiliser Quality Council, 2012a, b).
- **Runoff management:** Sources like yards, races, bridges, and silage heaps are managed to prevent significant point discharges.

While Overseer assumes these specific GMPs, it is capable of modelling the impacts of some poor practices, such as excessive nitrogen fertiliser in winter, over-application, over-stocking, or over-irrigation causing extra drainage.

2.3.2.4 Design principle 4: Using soil, climate and topographic slope data

Overseer uses farm-specific climate, soil conditions, and topographic slope in its calculations. This approach ensures Overseer results are farm-specific, enabling users to contextualize the impact of management strategies within the site-specific average climate, soil, and slope. Whilst initially a user input, 30-year average climate data is now derived automatically from the NIWA Virtual Climate Station Network (VCSN) dataset (See [6.4.0 release notes](#)). Using averaged climate removes the impact of yearly fluctuations in climate, allowing users to analyse strategic management choices rather than tactical ones, whilst still factoring in the farm-specific role of climate on nutrient flows and losses. Using averaged climate also aligns with the steady-state assumption, as Overseer is only designed to model the “average” representation of a given farm. This means that while users can and should

use actual farm data when they are describing their farm year-to-year, uncertainty is increased and care is needed when modelling or analysing farm management from a year of unusual seasonal conditions. Guidance for the reduction of this uncertainty can be found in the [Overseer Knowledgebase](#).

For soil information, users will ideally use the data from soil fertility tests in combination with auto-populated soil characteristics from the [Soil map \(S-map\) database](#). If S-map soil data is unavailable for certain management blocks on a farm, information from the [Fundamental Soil Layer \(FSL\) database](#) (which covers all of New Zealand) can also be auto-populated. However, as noted in the FSL website, the FSL database is considered outdated and less accurate than S-map. Given the high impact that soil has on nutrient flows on farm and thus in Overseer (Tavernet, 2022a), users are encouraged to use soil fertility analysis from standard laboratory testing following recommended soil sampling strategies ([Fertiliser Association booklets](#)), and soil characteristics from S-map if available.

When defining a block in Overseer, the model automatically assigns a slope category based on data derived from the [New Zealand Land Resource Inventory \(NZLRI\)](#). This dataset classifies land according to the slope categories used in Overseer: flat, rolling, easy hill, and steep hill. If the automatically assigned slope does not accurately represent the actual topography of the block, users can manually adjust the classification. Topography plays a crucial role in influencing nutrient runoff and leaching. Steeper slopes tend to increase surface runoff and nutrient loss, while flatter terrain generally enhances infiltration. By incorporating slope information, Overseer can more accurately simulate these processes, resulting in improved nutrient budgets.

2.3.2.5 Design principle 5: Known phenomena must be represented

As with any model, a core challenge in representing a real-world system is understanding the boundaries of the model's validity. Whilst a model's purpose and scope do much of the heavy lifting in defining this boundary, it is also often defined by data availability (or the lack thereof). A real-world farm system is a large and complicated biological system, where having uniformly sufficient levels of data and mechanistic understandings of this system is unlikely to ever be achieved. Indeed, Overseer exists in large part due to the immense challenge of measuring farm-scale nutrient flows and losses.

For this reason, Overseer was designed with the philosophy that capturing and accounting for the impact of as many farm management decisions as possible is essential. This philosophy intentionally challenges the scientific community to go beyond "insufficient data" as a reason for excluding a key phenomenon, promoting proactive approaches to include valuable insights wherever possible.

However, for this approach to be practically feasible and allow for suitable risk management, users and scientists alike need to appropriately understand the expected performance of the Overseer model in different conditions. For example, drainage modelling significantly impacts N and P loss values in Overseer. Thus, great care needs to be taken in modifying drainage modelling within Overseer and the highest quality input information should be provided to the drainage sub-model (e.g., high-quality soil, climate, and management data). For further help in understanding Overseer and its performance, the reader is directed to sensitivity and uncertainty information (Tavernet, 2022b), [model release notes](#), and [technical manuals](#).

2.3.3 Theoretical foundation

Overseer is rooted in the New Zealand agricultural scientific community, having been created and managed by scientists at AgResearch for most of its life. Well-established scientific principles underpin its nutrient cycling and GHG modelling and how it responds to changes in farm management.

Overseer's primary function is to track key nutrients (N, P, K, S, Ca, Mg, and Na) as they move through soil, crops, animals, and effluent systems on a farm. This involves modelling nutrient inputs, transformations, and losses, such as nitrogen leaching, volatilization, and denitrification, which are influenced by soil type, climate, and management practices. Additionally, special attention is given to nitrogen losses from urine patches, which are a significant source of leaching in pasture-based systems. For P and K, Overseer accounts for processes like weathering and slow nutrient release to estimate retention and movement. This is essential for assessing the potential risk of runoff to water quality.

In addition to nutrient budgets, Overseer includes modules for GHG emissions, calculating methane from livestock digestion and nitrous oxide from soil processes. Methane emissions are determined by factors like dry matter intake and digestibility, while nitrous oxide emissions depend on soil moisture and the presence of dung and urine patches. These emissions and nutrient loss calculations are designed to allow farms to consider and manage certain potential risks to the environment, especially through pathways like leaching, runoff, and volatilization.

Overseer's structure and equations for both nutrient budgets and GHG modelling are informed by New Zealand-based research, having been built on empirical data from New Zealand-based trials and established scientific principles in soil science, animal nutrition, and agronomy. Studies on nutrient response to fertiliser, soil hydrology, and livestock emissions underpin the model's core equations and parameters. Overseer Limited strives to maintain this scientific rigor through continuous improvement, which is done in collaboration with the

scientific community, including on-going validation against field data to ensure accuracy (Tavernet, 2023).

Lastly, through integrating soil tests and S-map, climate information from NIWA, and agricultural studies, Overseer aligns its nutrient budgets with the environmental and agricultural conditions unique to New Zealand, producing outputs that reflect real-world nutrient cycling including losses from the farm system to the environment across diverse farm systems.

2.3.4 Technical scope

The technical scope of Overseer is centered on modelling nutrient flows and losses within and up to the farm boundary (i.e., “to the farm gate”), providing a detailed nutrient budget for farm systems across New Zealand. Overseer is primarily designed to calculate nutrient flows for dairy, beef, sheep, and cropping, including farm systems with combinations of these farming practices. It can also model goat, deer, outdoor pig systems and some fruits including viticulture; however, it does not currently support dairy sheep farms (as of 2025). The technical scope of Overseer’s components are described in the sub-sections below.

2.3.4.1 Spatial and Temporal

Overseer operates within the defined farm boundary, tracking nutrient flows down to the bottom of the root zone (0.6 - 1.5 m) and into the air, including some indirect emissions for N₂O. The farm is divided into "management blocks" – land parcels with similar soil, climate, and management practices – to simplify calculations. Overseer produces annualised results, with user management inputs provided monthly. Whilst the model’s primary timestep is monthly, certain climate elements like daily rainfall and temperature are calculated daily and then aggregated to a monthly value.

2.3.4.2 Nutrient Budget

Overseer tracks the movement and transformation of key nutrients – N, P, S, K, Na, Mg, Ca, and acidity (H⁺). Nutrient budgets are calculated at the farm and block scale. The nutrient budget is a summary of nutrients entering the farm or block such as via nitrogen fixation, fertilisers and supplements, and how nutrients leave the farm or block in the form of products (e.g., meat, milk, crops, pasture, etc.) or through environmental pathways, including leaching, runoff, and gaseous losses. Inputs and outputs used to estimate the nutrient budget can be used to estimate the maintenance fertiliser required to maintain soil fertility on each land block – a core function of Overseer. Maintenance is the benchmark against which PKS and Lime recommendations should be made.

2.3.4.3 Hydrology and Environmental Risk

Overseer's hydrology sub-model calculates drainage and surface runoff, and is influenced by soil type, topography, and climate. Water movement affects nutrient retention and losses, making it key for tracking nitrogen leaching. Overseer's emissions model estimates methane from livestock digestion and nitrous oxide from soil and manure, helping farmers understand the nutrient flows for their specific farm system, including nutrient loss. Overseer's ability to model long-term annual average nitrate losses through leaching was determined to be "good" to "very good" for pasture and cropping systems, respectively (Tavernet, 2023).

2.3.4.4 Animal Metabolism and Intake

Overseer includes detailed animal intake models, calculating metabolisable energy (ME), dry matter intake (DMI), and nutrient intake. These models help partition nutrient intake between animal products and excreta (urine and dung), and the distribution of excreta around the farm, including to the paddocks, dairy sheds, feed pads, lanes and raceways. Emissions from manure are dependent on the place of distribution.

2.3.4.5 Crop and Pasture Growth

Overseer's crop and pasture models simulate nutrient uptake based on growth, soil nutrient availability, and environmental conditions such as climate and soil moisture. These models are parameterised for different crop species and pasture types, allowing nutrient uptake and cycling to be estimated across mixed farming systems. This includes crops that are either grazed in-situ or harvested and fed as supplements. It is important to note that pasture growth under grazing is primarily driven by estimated animal energy demand, whereas crop growth is determined by user-specified yield and harvest date. Where white clover is selected as part of a pasture type it performs an important role in the estimation of N fixation, some pasture nutrient concentrations, and pasture yield distribution through the year.

2.3.4.6 Effluent and Waste Management

The Overseer effluent model tracks nutrient flows through effluent management systems (dairy sheds, pads and associated structures), accounting for block application methods, timing, and volatilization. It assesses the impact of effluent management practices on nutrient losses and estimates soil nutrient availability and runoff potential from spraying.

2.3.4.7 Soil-Specific Calculations

Soil characteristics, such as anion storage capacity (ASC), pH, drainage, and organic matter, are integral to Overseer's soil-specific calculations, which ultimately influence nutrient availability, utilisation, and loss. Overseer accounts for soil differences within farm blocks, allowing it to reflect nutrient cycling at the block-scale for up to three different soil types.

2.3.4.8 Data Integration and Iterative Computation

Overseer integrates regional data, such as soil and climate information from S-Map (or FSL) and NIWA, respectively, with user inputs to align calculations with real-world conditions. The model's iterative computation across sub-models allows for feedback between soil, climate, and management systems, providing outputs that reflect interconnected farm dynamics.

2.3.5 Technical usage guidance

Below are the technical guiding principles for effective use of Overseer, which also highlights key technical limitations to be aware of. These technical guiding principles reflect and summarise the information provided in this section and are based on those originally published by Tavernet (2023), Overseer Limited's principal modeller, which in turn derive from a more complete set reported by Freeman et. al. (2016).

Technical principle	Explanation
<p>1. The use of Overseer must recognise that it only models some sources of nutrients.</p>	<p>Overseer currently models seven nutrients at the block scale, including N and P. For these nutrients, Overseer models losses from agricultural systems; it does not model nutrient losses from all activities that may occur in a catchment (e.g., losses from many point sources, landslips, some riverbed/bank erosion, and non-agricultural land are not accounted for).</p> <p>Importantly for P, Overseer does not explicitly model Critical Source Areas (CSA), potentially leading to underestimation of the actual P losses.</p>
<p>2. The use of Overseer must recognise that it does not model all farm management or mitigation practices and that there are some assumed management practices within the Overseer model.</p>	<p>There are some management practices that are applied on farms that, although are understood to impact some nutrient losses, are not captured in Overseer, e.g., contour ploughing or management of break feeding.</p> <p>There are also “good management practices” that are assumed to occur on all farms modelled in Overseer. If practices occurring on farms are not modelled by Overseer, or the assumed good management practices are not being applied, the modelled losses may be over- or under-estimated relative to the actual losses from the farm.</p>
<p>3. The use of Overseer must recognise that it only estimates nutrient losses from the farm boundary and root zone.</p>	<p>Overseer estimates nutrient loss from a farm (through leaching, runoff, and direct to streams) as losses from the farm boundary or root zone (below 1500 cm). It also estimates losses to atmosphere for CH₄, N₂O and CO₂.</p>
<p>4. The use of Overseer must recognise that it is a steady-state model and does not model the effects of transition, e.g. transition from dryland to irrigated or farm system changes such as the conversion from forestry to pastoral farming.</p>	<p>When a system is in transition, there are likely to be soil processes occurring that significantly impact the actual nutrient losses during the transition period. However, Overseer assumes near-equilibrium (i.e., steady-state) farm systems, so the losses occurring as the system changes are not captured. Therefore, OverseerFM may underestimate or overestimate losses during a transition period.</p>
<p>5. The use of Overseer must recognise that data used to run the model (actual or estimated) need to reflect a long-term, chemically and biologically feasible farm system.</p>	<p>Overseer does not rigorously validate the production data entry into the model. Overseer assumes that the system being described by the user is chemically and biologically feasible. This means that, as of 2025, implausible farm systems can potentially be modelled.</p> <p>Also, a farm practice may be viable for a short time, e.g., mining soil nutrients. However, if this is not feasible in the long term, the estimated losses of these “short-term” practices may underestimate the actual requirements and effects of that farm system over the longer term.</p> <p>Data provided to Overseer can be from actual farm data or estimated data. Where actual farm</p>

	<p>data is used, it should be consistent with technical principle 7. Where estimated, data inputs should be supported by either other modelling (e.g., Farmax or crop calculators) or farm system expertise.</p>
<p>6. Overseer requires significant expertise to enable farm systems to be modelled accurately, and the user must recognise that the quality of the data inputs impacts the uncertainty associated with the estimated nutrient losses.</p>	<p>As with any model, if the input data and modelling methodologies used to run Overseer are poor the quality of the model results will degrade. This means there is high uncertainty associated with the nutrient budget and estimated losses generated by Overseer when using this poor input data.</p> <p>Therefore, it is critical that high quality data is used, and careful use of Overseer is achieved when using Overseer results to inform real-world decisions. As of 2025, using Overseer in this way requires significant expertise.</p>
<p>7. The use of Overseer must recognise the long-term climate input assumptions built into Overseer and choose data inputs consistent with those assumptions.</p>	<p>Overseer assumes that the farm system being described is a stable long-term system, including the presence of stable average climate conditions. Any modelling of a specific farm in a way that does not match these assumptions is likely to increase the uncertainty of the estimates Overseer provides. Therefore, Overseer data inputs should be consistent with these climate assumptions.</p>
<p>8. The use of Overseer must recognise the differences in N and P loss processes and how these are modelled in the Overseer model.</p>	<p>Overseer models N and P flows using fundamentally different approaches, which has important implications for estimating nutrient losses and evaluating mitigation strategies.</p>

3 References

DairyNZ (2012). Environment: Managing/Operating Effluent Systems. Retrieved 2015 from: http://www.dairynz.co.nz/page/pageid/2145874053/Managing_Operating_Effluent_Systems

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. Available from: [2016 - Freeman et al. - Using Overseer in Regulation - a guide for councils – Overseer Knowledge base](#)

MPI (2023). Overseer Redevelopment Programme Report. MPI. Available from: <https://www.mpi.govt.nz/dmsdocument/59020-Overseer-Redevelopment-Programme-Report>

New Zealand Fertiliser Quality Council (2012a). Fertmark Code of Practice. Retrieved 2015 From: <http://www.fertqual.co.nz/download.php?view.1>

New Zealand Fertiliser Quality Council (2012b). Spreadmark. Retrieved 2015 from: <http://www.fertqual.co.nz/page.php?11><http://www.fertqual.co.nz/page.php?11>

Science Advisory Panel (2021). Overseer whole-model review: Assessment of the model approach. MPI. Available from: <https://www.mpi.govt.nz/dmsdocument/46360-Overseer-whole-model-review-Assessment-of-the-model-approach>

Tavernet, J.P., Harper, J. (2022a). Sensitivity analyses on nitrate loss at the farm level estimated by the Overseer science model. Overseer Limited. Available from: https://assets.ctfassets.net/bo1h2c9cbxaf/1k2maX4yQvUpTW8LXY3rBJ/e5a707917ef63c7a7b320062a8b13665/Sensitivity_report.pdf

Tavernet, J.P., Harper, J. (2022b). Uncertainty analysis – propagation of input climate data and soil uncertainties on nitrate-loss estimated by the Overseer science model. Overseer Limited. Available from: https://assets.ctfassets.net/bo1h2c9cbxaf/4HprUvSG1fiB7eeoRJgrxW/40a39b19ac30c3d49dcfdc818c62a436/Uncertainty_analysis_report.pdf

Tavernet, J.P. (2023). Assessment of Overseer model performance with experimental data from grazed pastures. Overseer Limited. Available from: https://assets.ctfassets.net/bo1h2c9cbxaf/7hFbaY3PH76sXg5butruk/8423911da88c3a2f985ad5c5c889ee44/23_09_04_Assessment_of_the_OverseerFM_model_performance_with_experimental_data_from_grazed_pastures_JP_Tavernet.pdf

Wheeler, D. (2018). OVERSEER® Technical Manual: Introduction. AgResearch. Available from:

https://assets.ctfassets.net/bo1h2c9cbxaf/246EMt5pZeaBPwqAM4p0pW/e40b2b20d807bcd a77afc6939b0b183e/Introduction_Nov_2016_.pdf