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Technical Description of OVERSEER for Regional Councils

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Technical Description of OVERSEER for Regional Councils

Report prepared for Bay of Plenty Regional Council

September 2015

Natalie Watkins and Diana Selbie

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Executive Summary

OVERSEER® Nutrient Budgets (OVERSEER) is an agricultural management tool which assists in examining nutrient use and movement within a farm, as an aid to optimise production and to reduce nutrients losses from the farm. OVERSEER calculates and estimates the nutrient flows in a farming system and can be used to identify potential risks to the environment through the calculation of nutrient loss through run-off, leaching, and greenhouse gas emissions. The core of OVERSEER is a nutrient budget. The nutrient budget shows the inputs and outputs of a farm system. From this information reports are prepared so that maintenance nutrient and lime recommendations, nutrient use efficiency and potential losses to the wider environment can be assessed.

OVERSEER as we know it today has a long development history and is based on many years of scientific research, primarily undertaken in New Zealand. OVERSEER was first developed in the early 1980s. Over the past three decades OVERSEER has undergone numerous improvements and developments. As science continues to provide new knowledge OVERSEER is continually refined.

The farm systems that can be modelled within OVERSEER include; pastoral, horticultural, arable and vegetable. OVERSEER models seven nutrients (nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), and sodium (Na)), and for pastoral blocks acidity. Greenhouse gas emissions and energy emissions on a per hectare basis or a product basis are also provided. OVERSEER requires a wide range of inputs to be able to create a farm file. The nature of the inputs required will vary depending on the farm system being set up. One of the original development goals of OVERSEER was that the model required information that was easily-available from farmers and where the information may not be readily available suitable defaults have been built into the model.

The OVERSEER boundary is the farm boundary, which does not need to be spatially contiguous and the bottom of the root zone (60 cm). OVERSEER does not take account of nutrient losses in the vadose zone (area between the root zone and the receiving water body). As with all models, OVERSEER has limitations. Limitations exist around the fact that OVERSEER is not a spatially explicit model and therefore doesn't take into account critical source areas on a farm. OVERSEER does not take into account sediments, E-coli or other pathogens. OVERSEER does not represent all farm systems and management practices that occur within New Zealand and cannot be validated

against every combination of enterprises, climate and soil type etc. In saying this, nor can any model. However, the benefit of OVERSEER is that it does this by extrapolating out to these areas based on robust scientific principles.

All models have a series of assumptions and design criteria that underlie the model. In terms of OVERSEER, the key assumptions are that it assumes the farm is operating in a 'steady-state' and actual and reasonable inputs are entered. One of the key design criteria underlying the development of OVERSEER is that the outputs are long term annual average outputs. This is primarily due to OVERSEER outputs being calibrated against research trials where management was constant and/or measurements averaged across several years.

A key question often asked around OVERSEER is what is the error, accuracy or uncertainty of model outputs. The most relevant term to OVERSEER is uncertainty. OVERSEER was designed to accommodate the use of easily obtainable data, which means that the model uses simplifications of complex processes. The estimates resulting from these simplifications will always involve uncertainties. All models involve a level of uncertainty. Uncertainty in OVERSEER can be split into two types; measurement and modelling. Measurement uncertainty includes the variability inherent in nature as well as variability associated with scientific experimentation. Modelling uncertainty includes data input, errors in interpretation and extrapolation of science information and model coding, and the unknown 'unknowns'.

Sensitivity analysis can provide an indication of which model parameters or attributes of the farm system have the greatest influence on outputs. In general, the main inputs that have the most influence on nutrient loss estimates are inputs that influence the size of source of a nutrient (e.g. stocking rate, fertiliser inputs) and inputs that influence the transport of a nutrient (e.g. rainfall/drainage, soil type, slope).

OVERSEER as it stands today is an incredibly unique and powerful tool that can help the New Zealand agricultural industry meet the growing pressure on managing nutrient losses from land.

Glossary of terms

Assumption: A statement which is assumed to be true within the model.

Block: The sum of areas of the farm that are managed the same (e.g. irrigated, cropped, effluent applied) and have the same bio-physical attributes (e.g. soil type, topography).

Calibration: The process of adjusting numerical or physical modelling parameters in the computational model for the purpose of improving agreement with experimental data.

Design criteria: The explicit goals that have determined the models structure.

Evaluation: All quantitative and qualitative methods for evaluating the degree to which a model corresponds to reality.

Engine: Calculation model within OVERSEER. This uses inputs from an interface or file and produces the outputs.

Enterprise: Within OVERSEER enterprise refers to the animal types present on farm e.g. dairy, dairy replacements, sheep, beef, deer, dairy goats, and others are recognised.

Land use: The management unit of interest. OVERSEER models pastoral, horticultural, arable and vegetable land uses and these land uses can all be integrated into one OVERSEER nutrient budget if required.

Limitation: Something that bounds or restricts the models use.

Nutrient: Seven nutrients are modelled in OVERSEER; nitrogen, phosphorus, potassium, sulphur, calcium, magnesium and sodium. Within the pastoral model, change in acidity (H+) is included for the determination of lime maintenance requirements.

Nutrient budget: Report of net inputs and outputs to a given scale (block, farm), defined system over a fixed period of time.

Nitrogen conversion efficiency or Nitrogen Use efficiency: product N / N input, where N inputs include fertiliser, supplements and N fixation.

Nitrogen surplus: The difference between inputs and removals by plants.

Nutrient transfer: Spatial and temporal movement of nutrients between locations on a farm e.g. effluent applied to a block, or nutrients being consumed in one place and deposition as excreta in another.

OVERSEER**:** the software that comprises the engine plus input data (interface) and data storage systems.

Quasi-equilibrium: The model assumes that inputs and farm management practices described are in quasi-equilibrium ‘steady-state’ with the farm production.

Relative yield: Predicted relative pasture yield relating to nutrients applied (fertiliser).

Sub-models: A distinct part of the OVERSEER engine.

Uncertainty: The potential limitation in some part of the modelling process that is a result of incomplete knowledge.

Validation: A comparison of model results with numerical data independently derived from experiments or observations of the environment (a part of the wider evaluation).

1. Introduction

OVERSEER is a unique model that assists in examining nutrient use and movement within a farm as an aid to optimise production and to reduce nutrients losses from the farm. OVERSEER has huge benefits to the New Zealand agricultural industry and has become a widely-used tool in managing nutrient losses from farm systems. OVERSEER has a long history of collaboration between the government, the fertiliser industry and agricultural scientists.

There are numerous technical and science papers available that describe the underpinning science behind OVERSEER and provide detailed explanation of how components of the model work. However, this work is often of a very technical nature and is not always suitable for a wider audience, such as regional council staff that require a greater level of understanding of OVERSEER. Due to this gap in required information, regional councils have initiated a collaborative project with industry to develop guidance material on the appropriate use of OVERSEER. The starting point for developing this guidance material is this report "Technical description of OVERSEER for Regional Councils".

The aim of this report is to provide a high-level summary of OVERSEER in terms of; what OVERSEER is, how it works, key inputs and outputs, history, a description of the nitrogen and phosphorus sub-models, scale and limitations, key assumptions, model uncertainty and sensitivity of outputs to inputs.

The objectives of this report are:

1) To provide regional council users of OVERSEER with a simple description of the model, including what it can do, and its outputs, assumptions and limitations.
2) To inform the development of guidance material for regional councils on the appropriate use of OVERSEER in policy, regulation, compliance and advice.

2. What is OVERSEER?

OVERSEER Nutrient Budgets® (OVERSEER) is a computer software model that reports or estimates nutrient use and movement within a farm system. OVERSEER is used to provide information on nutrient losses from farms and support decision making on New Zealand farms (Figure 1). OVERSEER models a wide range of farm and management practices within New Zealand. The farm systems that can be modelled within OVERSEER include a mix of pastoral, horticultural, arable and vegetable systems. The pastoral model also includes fodder crops and cut and carry systems. OVERSEER models seven nutrients: nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), and sodium (Na), and for pastoral blocks acidity, which is linked to maintenance lime requirements. Greenhouse gas emissions and energy emissions on a per hectare basis or a product basis are also provided (Wheeler and Shepherd, 2013a).

A farm 'nutrient budget' is the main output produced by the model, which is a summary of the various movements of nutrients through the farm system during the year. The model reports the nutrient budget as a table of nutrient inputs, outputs and transfers on an annual basis. Before a nutrient budget is produced, a series of steps is completed whereby information is entered that describes the farm system. This input information includes a range of bio-physical attributes (climate, soil, plant, animal) as well as management decisions and events in the farm calendar (e.g., feeding animals, applying fertiliser, ploughing a paddock).

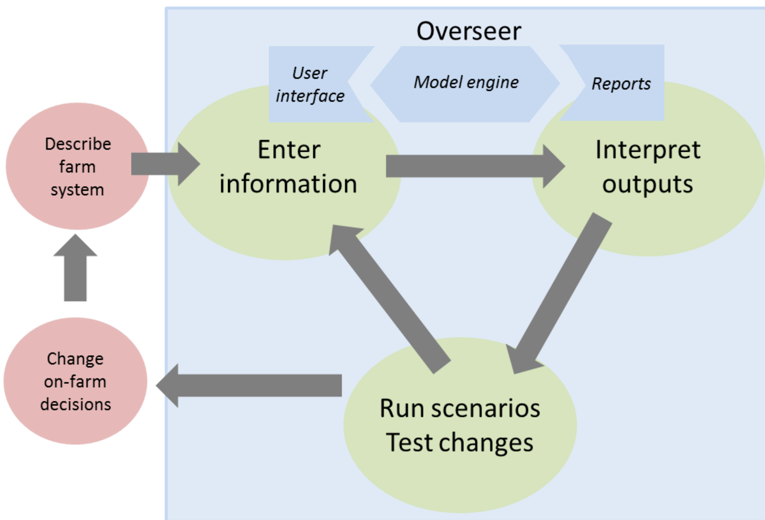

Figure 1: OVERSEER is used to provide information and support decision-making around nutrient management on New Zealand farms.

Managing the nutrients coming into, moving around, and leaving the farm is one important way of improving the profitability and sustainability of a farm business. As nutrient loss and environmental consequences of nutrient loss from farms continue to be of concern to the wider community, it is important to provide options for improving nutrient management on farms in order to utilise nutrients more efficiently. While OVERSEER is primarily used to support decision-making on farms relating to nutrient management, there are a number of additional uses, including:

- Maintenance fertiliser nutrient recommendations, which can be used to derive fertiliser recommendations for pastoral blocks.
- Environmental footprinting (providing an estimate of nutrient losses from the farm to air (e.g., greenhouse gases) and water (e.g., leaching, run-off).
- Scenario testing (testing a range of management changes for a targeted outcome e.g., environmental mitigation).
- Identify nutrient hotspots (e.g. high nutrient loss blocks) and optimise effluent block areas to ensure correct amounts of N and K are being applied.
- Benchmarking (providing a status report to be used as a baseline for comparison e.g., with future reports or against other farm reports within a catchment).
- Monitoring – for assessing the change in nutrient losses over time.
- Policy and limit setting (nutrient reports being used to establish an appropriate discharge limit from a farm and track changes in relation to the set limit (e.g., nutrient loss to water).
- Scientific research (testing hypotheses and conducting investigations e.g., “what if” questions).
- As an education tool (describing and understanding implications of nutrient management on New Zealand farms e.g., in agricultural qualifications at Universities).

The model is designed based on science principles that are derived from a large body of scientific research into nutrients and how they behave in the environment, as well as assumptions where there are knowledge gaps. Model outputs are evaluated and calibrated based on measurements made in the field that capture the wide range of farm system attributes around New Zealand. While OVERSEER may be operated by nearly anyone, the best use and interpretation of OVERSEER is by those who are formally trained and understand farm systems.

3. How does OVERSEER work?

OVERSEER aims to capture the transfer of nutrients through the farm, in terms of how much each nutrient moves where, and when. To do this, OVERSEER utilises the input information the user has entered as well as default values, and this information is then run through a series of sub-models to produce a series of reports, including the nutrient budget (Wheeler & Shepherd, 2013b). Sub-models are a combination of science principles and assumptions that are simplified to describe nutrient use and movement. OVERSEER consists of over 20 sub-models (hydrology, climate, animal intake etc.).

OVERSEER requires information about the farm at two levels; farm and management block level. The farm level inputs describe the general farm structure and enterprises. A management block within a farm system is defined as the sum of areas of the farm that are managed the same (e.g. irrigated, cropped, effluent applied) and have the same bio-physical attributes (e.g. soil type, topography). OVERSEER models nine management block types (Table 1). The splitting of the farm into management blocks is a critical part of correctly setting up the model to produce meaningful outputs (Figure 2). The fate of nutrients within a block and the farm as a whole plus the transfers between blocks and structures is the focus of most of the modelling carried out in the OVERSEER engine e.g., where and when animals excrete and deposit nutrients in paddocks, laneways and feed pads.

Table 1: Management blocks in OVERSEER.

Management block	Description
Pastoral	Grows pasture (i.e. non-effluent or effluent pasture block) which animals graze, and a proportion can be removed as supplements. Key feature is pasture and animals grazing that pasture.
Fodder crop	Grows a fodder crop, the crop is planted and re-sown back into pasture within a 12 month period (i.e. swedes). Key feature is the 1-year fodder crop that rotates within pastoral block(s).
Crop	Grows an arable or vegetable crop (i.e. wheat or potatoes) (and fodder crop rotations when the return to pasture is >12 months). Can include grazing animals, depending on crop. Key defining feature is the crop rotation over a 2 year period.
Cut and carry	Grows a perennial pasture where all forage is removed (i.e. grass or lucerne). Key defining feature is that all growth is removed as supplements, and no animal grazing occurs.
Fruit crop	Grows a permanent fruit crop on it (peaches, apples,

	kiwifruit, grapes and avocados). Can include grazing animals. Key defining feature is the management of the fruit crop.
Riparian	Area of land fenced off on either side of streams or rivers where animals are excluded. Key defining feature is the description of the riparian strip.
Trees and scrub	Area of land covered in trees, scrub or native bush.
Wetland	Area of land fenced off to all grazing where there is a wetland. Key defining feature is the description of the wetlands
House	Area of land within a farm that contains a house and surrounding gardens, no animal grazing occurs. Note that this does not apply to urban properties.

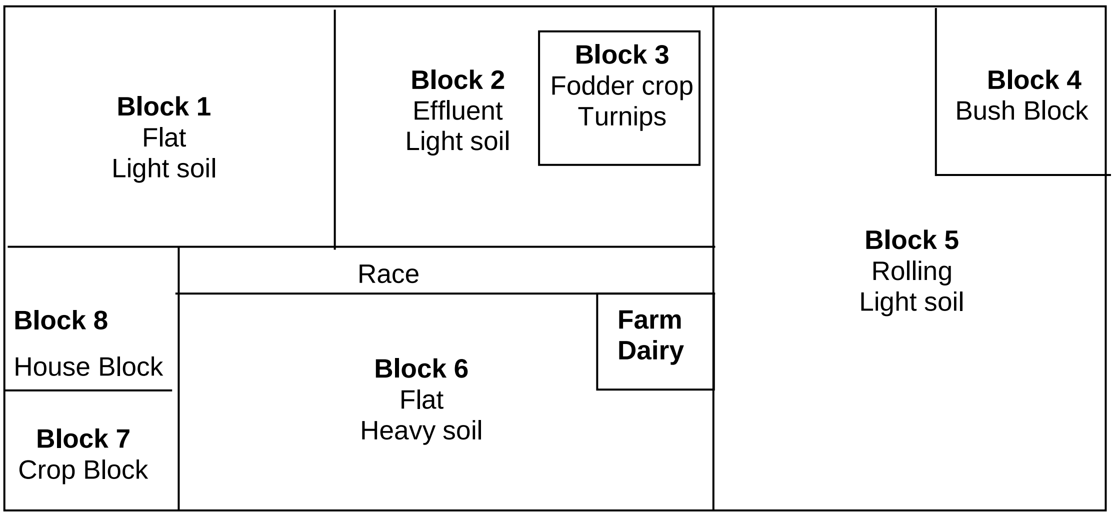

Figure 2: Schematic diagram highlighting potential farm management blocks.

Blocks identified in OVERSEER do not need to be contiguous. Thus for example, OVERSEER can model a farm with a run-off block beside the farm, or in the next catchment. For example, for a dairy farm with a run-off block, the definition of the farm and arrangement of blocks depends on how easy it is to split management, and the desired use of the model. If OVERSEER is being used to look at the effect of the whole farm management system, a run-off block is included within the farm wherever that block is located. If looking at catchment specific outputs, the runoff block may be modelled separately if the management of that block can be clearly separated. However, if the management is fully integrated in with overall farm management, the ability to separate out individual block management may be compromised.

3.1 OVERSEER inputs

OVERSEER requires a wide range of inputs to be able to create a farm file. The nature of the inputs required will vary depending on the farm system being set up. One of the original development goals of OVERSEER was that the model required information that was readily-available to farmers and, where the information may not be readily available, suitable defaults have been built into the model. Based on this design criteria OVERSEER has a three-tiered approach to data inputs:

1. Compulsory inputs
2. Optional inputs
3. Default values (which can be overridden)

The nature of the inputs required to be entered into OVERSEER can be generalised into two groups. Inputs required at the farm level and inputs required at the block level. These tend to reflect the scale of decision-making, for example decisions on land use, stock policy and farm structures (e.g., feed pad) are typically made at the farm level, whereas, fertiliser application, crops grown and grazing management are made at the block level. Table 2 below provides a summary of the type of information required for OVERSEER. *Note* this table is not an exhaustive list of OVERSEER inputs. It is also worth noting that OVERSEER models crop rotations over a two-year time period, so inputs entered and information required for crop blocks can be significant.

Table 2: Summary of the type of information required to set-up an OVERSEER farm file.

Farm level	Block level
Farm location Types of blocks and block areas Types of (enterprises) stock - Stock numbers, breed - Production - Placement (grazing off, wintering pads) Types of structures - Effluent management of structure - Stock management on structure Type of effluent management system Supplements imported and where they are fed Wetlands	Topography Climate Soil type Drainage Soil tests Pasture type Supplements made Fertiliser applied Irrigation applied Effluent applied Animals (type, timing) grazing the block Crop rotation; crops grown – yield, fertiliser applied, harvesting method

User selection of the input parameters can have a major effect on the estimates of nutrient cycling for the described farm systems and ultimately, nutrient budget reports. To ensure consistency between different users when operating OVERSEER to model individual farm systems OVERSEER has developed the 'Best Practice Data Input Standards'. The standards provide expert users with guidance for data inputs that consistently achieve the most meaningful result. One of the key strengths of OVERSEER is the ability to test a range of different mitigation scenarios for a given farm system. To achieve this for pastoral systems, OVERSEER uses stock production to estimate pasture production. If undertaking mitigation analysis where pasture production may change, it is important to make subsequent changes in animal production to ensure the farm system remains feasible e.g. if reducing N fertiliser rates, you will either need to reduce fertiliser inputs and lower cow numbers or buy in more supplements if production is to remain the same.

Built into OVERSEER is a range of different databases. These databases provide information to OVERSEER to establish background defaults used in the model. The databases built into OVERSEER are summarised in Table 3. All the built-in databases within OVERSEER have some level of uncertainties and limitations associated with them.

Table 3: Built-in databases in OVERSEER.

Type of database	Why we use them	Major Source
Climate data*	Provides long-term estimates of annual rainfall, PET and annual temperature (30 years) of climate data for New Zealand. Based on a 5 km grid dataset.	NIWA
Fertiliser and lime product data	Provides the nutrient content for a range of fertilisers.	Ballance and Ravensdown
Salt blocks	Provides the nutrient content for a range of salt blocks or licks.	Summit
Supplements data	Provides the nutrient, DM, ME content of a range of common supplements imported on a farm.	FeedTech
Soil data	Provides a range of soil properties values.	National soils database, AgResearch
Crop data	Parameters that define the growth uptake and nutrients.	Plant and Food

*The Climate data database is an online database, it is only available when the user is connected to the internet.

3.2 The OVERSEER nutrient budget

The main output produced by OVERSEER is a ‘nutrient budget’. A nutrient budget is a summary of annual inputs and outputs and the various movements of nutrients through the farm or block during the year. The outputs are the annual average losses, assuming the inputs (management) are constant over time, for the given site characteristics.

For each farm system modelled in OVERSEER an annual average nutrient budget is produced for each block within the farm and a whole farm nutrient budget is produced. The nutrient budget report can be broken down into three sections with the unit's kg nutrient/ha/yr; 1) nutrients added, 2) nutrients removed and 3) change in soil and plant nutrients pools, with a schematic diagram shown in Figure 3 for a block.

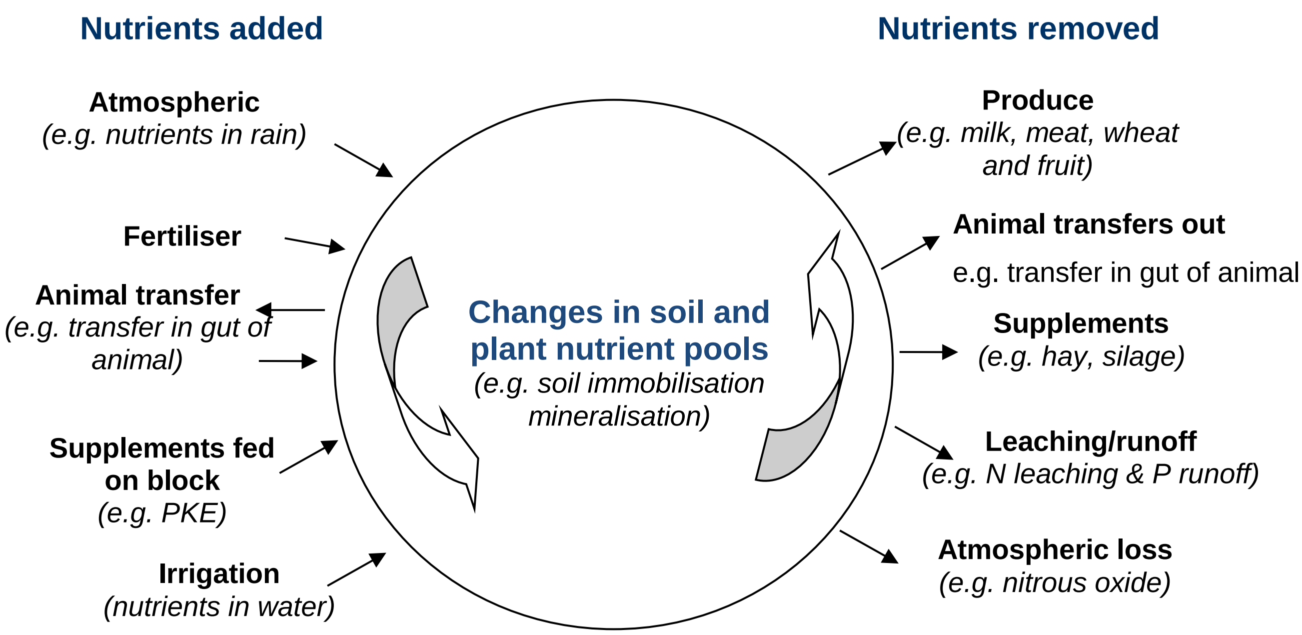

Figure 3: Schematic diagram of a pastoral block nutrient budget, showing typical nutrient inputs and outputs of a farm system. An arable block nutrient budget would be the similar to the above diagram, except standing plant material, root and stover residuals are included in the changes in soil and plant nutrient pools.

3.3 Other reports produced in OVERSEER

The ‘nutrient budget report’ is one of the key reports (outputs) from OVERSEER however; a number of other reports are produced in OVERSEER (Table 4).

Table 4: Key reports and outputs produced in OVERSEER. Reports are shown at the farm scenario level and the block level.

	Description of key outputs shown in the reports
FARM SCENARIO REPORTS	
Nitrogen Report*	• Total N lost (leaching, runoff, direct to stream, etc) to water (kg N/yr and kg N/ha/yr) for blocks and farm. • Average N concentration in drainage (ppm), based on N leached. • N surplus per block (kg/ha/yr).
Phosphorus Report*	• Total P lost to water (kg P/yr and kg P ha/yr) for blocks and farm. • Categorises the greatest P loss areas i.e. soil, fertiliser or effluent as High, Medium or Low risk.
Comments*	• General comments on the outputs, block specific comments supplied in the block comments report.
Summary Report	• N conversion efficiency (%). • Effluent area required to achieve applications rates of 150 kg N/ha/yr. • Total greenhouse gas emissions.
Nitrogen Overview	• Farm average inputs of N (clover N, fertiliser N and other N added. • Farm average N loss to water, N_2O emissions, Farm N surplus and N conversion efficiency.
Phosphorous Overview	• Farm average inputs of P (fertiliser, supplements and other P added). • Farm average P loss to water and P surplus. • P loss risk categories (soil, fertiliser and effluent).
Greenhouse gas reports: - Greenhouse gases - Energy - Footprint units - Footprint product	• Total NH_4, N_2O, CO_2 emissions (%) produced and source of emissions. • Total energy used on farm (MJ/ha/yr). • Greenhouse gas (CO_2 equivalents/unit) and energy (MJ/unit) per enterprise and per product.
Effluent Report	• Current area receiving liquid effluent. • Average amount effluent applied and N content. • Area of farm required to receive effluent to achieve target rates N and K. • Source of N.
Pasture Production Report	• Estimated Pasture intake and production on each block (kg DM/ha/yr), utilisation (%), supplements removed (kg DM/ha/yr) and current animal intake (kg DM/ha/yr).
Animal reports	• Reports on the location, estimated feeding amounts, and stocking rates (RSU).
Other values report	• Milking herd size, Milk production (kg/ha and kg MS/cow), total live weight brought, reared and sold, RSU.
Animal reports	• Series of reports that show animal location of a farm, and the amount of feed (ME and DM) fed to animals at different places each month.
Full parameter report	• Downloadable report which details the information entered or used by OVERSEER to generate the reports.

BLOCK REPORTS**	Description of key outputs shown in the reports
Graph N pools	• Graph of the calendar year showing how the model soil N pool changes in pasture background N model blocks (kg/ha/month). • For crop blocks (arable and vegetable, fruit, cut and carry systems) how model soil N pool, plant N, residue root N and residue stover N change.
Graph changes in N pools	• Graph of the calendar year showing how N pools (kg/ha/month) change. For the pastoral blocks, only the background model is shown.
Maintenance fertiliser nutrients	• Estimated fertiliser nutrient and lime rates for each nutrient (except N) to maintain soil test levels (pastoral block only).
Relative yield	• Predicted relative yield (%) for each nutrient (pastoral only).
Other values	• Relative yield, pasture utilisation, climate data, irrigation applied, drainage, soil properties.

*The nitrogen, phosphorus and comments reports are both available within the Farm Scenario and Block reports

**The type of Block reports supplied will vary depending on the block types.

3.4 Software data and links to other models

OVERSEER consists of four components:

1) The interface. This is the part of the software that the users interacts with to add input data, and to see the outputs. The interface interacts with the engine by sending information to it and receiving it back via the data structures, and saving the input data.
2) The data structure. OVERSEER uses standard XML to move data around, and to save data as a file.
3) Data storage. The internet version of OVERSEER stores its data in a secure database on a server. This means that the data is available wherever there is web access. Other systems use a custom database e.g. when engine is linked to a customer management system.
4) The engine. This is the part of the software that reads the data and undertakes the calculations, and produces the output results.

Note that there are two Overseer products – the public internet and standalone. These two use the same interface, data structure and engine. The stand-alone version uses a database on the computer it is installed on, and uses an emulation package so that the interface can by shown in the same way as the internet based product.

The components used depend on how a user interacts with OVERSEER. Most users use the internet version of the model, which uses all four components. Another model, such as CLUES, uses the GIS component to provide the data, and interacts directly with the engine. The crucial part is that for a given version number, the engine is the same for all uses.

OVERSEER is updated at regular intervals to fix known problems, add in new science, to improve existing features (enhancements) or add new features. Each release has a version number associated with it. The OVERSEER application version numbering system takes the form x.y.z. X is the major version number (this number changes if there is major change to the model as a result of a major change in design criteria or a change in structure, for example the change from a windows based to internet based system), y is the minor version number (this number changes if there are functionality changes due to new science or the addition of significant new features) and z is the patch version number (this number changes if there are maintenance (bug) fixes or minor functionality changes). Each number must increase numerically at the time of any new OVERSEER releases and all releases will include the three version numbers. What the new version number of OVERSEER is at the time of release will be directly related to the nature of the changes that have occurred within the model. Once the new version of is released, previous versions of OVERSEER are no longer available.

4. History of OVERSEER

OVERSEER as we know it today has a long development history (Table 5). Table 5 highlights the major developments and changes that have occurred since OVERSEER or its predecessors first began in the 1980's as a Computer Fertiliser Advisory Scheme (CFAS) (Wheeler and Shepherd, 2013). The model has progressed in response to external drivers such as nutrient use efficiency, environmental outputs and more lately regional council requirements, and as scientific information has become available.

Table 5: Timeline showing major developments of the OVERSEER® nutrient budget model or its predecessors.

Year	Model	Description	Outcomes
1982-84	CFAS	The CFAS was a first attempt to summarise all available fertiliser research. And to provide standardised fertiliser advice	Estimated fertiliser requirements based on calculated inputs and outputs

1996	Outlook	Incorporation of results from the analysis of databases summarising all P, K, S field trials in NZ.	Improved predictions of plant nutrient concentrations and relative yield. Inclusion of economic information.
1999	PKSLime model	Addition of lime trial information.	Capital lime recommendation model added.
2000	OVERSEER® 2	International concern about the role of farm nutrients in environmental degradation required a need to estimate N loss.	First publically available nutrient budget model. Environmental focus (N). Development of separate crop and horticultural models.
2000	OVERSEER® 3	Combined PKSLime model (productivity and econometric) and OVERSEER® 2 nutrient budget (environmental) into a single model. This is now known as the econometric model, which is a proprietary software	Productivity, econometric and environmental model.
2002	OVERSEER® 4	OVERSEER® 2 was expanded to include environmental reports, winter management options and a wider crop range. Block scale model.	Winter management options and wider crop range.
2003	OVERSEER® 5	The first whole farm system nutrient budget model. Could predict nutrient transfers of nutrients between different management blocks.	Additional nutrients Ca, Mg, Na and acidity, greenhouse gas and energy resource reporting, monthly animal inputs, scenario analysis and additional reports.
2005-2009	OVERSEER® 5.2-5.4	Increased use in evaluating farm management effects on nutrient flows and environmental emissions. Interest in possible regulatory role.	Addition of P runoff loss model, fodder crops, pig effluent and house blocks. Pad system upgraded, including the addition of animal shelters and associated effluent management systems. Inclusion of nitrification inhibitors, wetlands and riparian strips. Crop and horticultural fruit models were overhauled.
2012	OVERSEER® 6	Integration of all models into a single model and the	Pasture, crops and horticultural blocks all

		development of a new architecture.	linked into one model. Addition of cut and carry blocks, dairy goats and an upgrade of the effluent management system. Introduction of the monthly N leaching model and life cycle assessment (LCA) methods for greenhouse gas emissions.
2014	OVERSEER® 6.2	Upgrade of the Irrigation sub-model to better account of wider range of irrigation management practices.	Upgraded irrigation sub-model.

5. The OVERSEER 'engine'

5.1 A pastoral farm as an example

The model engine that estimates the nutrient movement around the modelled farm is made up of a series of sub-models (Figure 4). The interaction of the sub-models produces the final outcome, the nutrient budget. The sub-models within OVERSEER can be classified as '**component sub-models**', e.g. Climate, Hydrology, Animal energy requirements, Animal intake and excreta, Urine patch model, Effluent additions and Crop growth. The component sub-models are then combined to build '**block sub-models**', e.g. Pastoral, Crop and Cut and Carry sub-models. Outputs from the block sub-models are then combined with '**farm-based sub-models**', e.g. pad management, effluent system to produce the overall '**farm sub-model**' for the particular farm being modelled in OVERSEER.

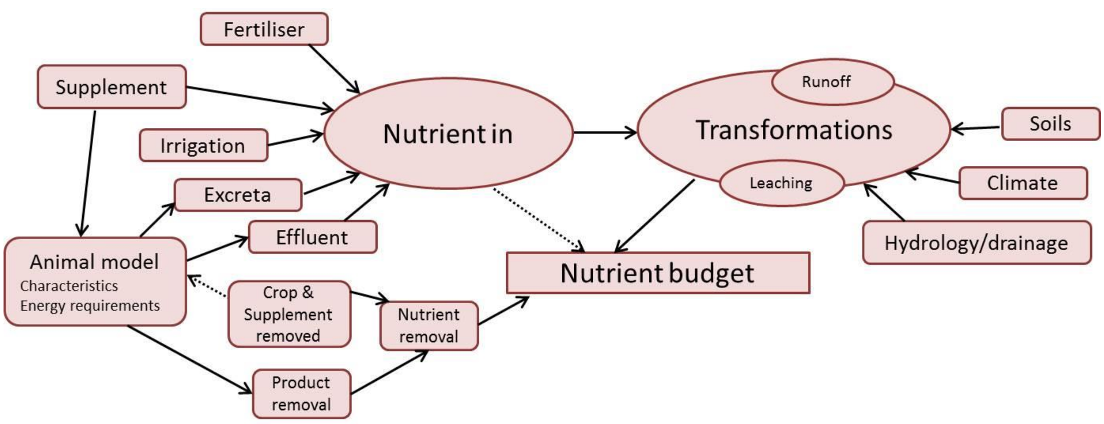

Figure 4: Generalised diagram of sub-models making up the OVERSEER model engine for a pastoral farm.

Much of the OVERSEER modelling is about tracking nutrient flows, which means understanding the spatial (and often temporal) movement of nutrients. A number of component sub-models are focused on this spatial and temporal nutrient movement (e.g., block transfers) whereas others capture the fate of these redistributed nutrients (e.g., urine patch sub-model). The following description illustrates how a nutrient (e.g., N) in a 'real' farm can undergo several transfers and fates that need to be captured before a nutrient budget can be produced.

Grazing animals consume pasture containing N. The amount of pasture dry matter (DM) consumed depends on animal production (via the animal energy requirement sub-model), and the N content of the consumed pasture (pasture growth and pasture nutrient sub-models). Grazing animals also consume supplements containing N (supplement sub-model). Of the total N consumed, some is used to produce products (e.g. live weight, milk, wool, velvet) the rest is excreted as urine and dung (excreta sub-model). The excreted N can be deposited onto blocks, laneways or in the milking parlour and thus entering the effluent system and applied to the effluent block. The excreta N which is returned to the pastoral blocks can be taken up by the pasture again and/or a proportion can be lost to the air (e.g., via volatilisation and denitrification) or into drainage water (e.g., via leaching when the soil is draining).

OVERSEER's block nutrient budget captures the transfer of N in and out of the block. The farm nutrient budget captures the transfer of N in and out of the farm. This may include transfers in and out of block (e.g. fertiliser in, supplements exported), farm structure losses, and area weighted average losses such as N leaching or volatilisation. Internal transfers such as effluent movement, or supplements grown and feed on the farm shown in the individual block nutrient budgets but are not included in the farm nutrient budget as the nutrients do not cross the farm boundary.

In this report we focus on the N and P sub-models within OVERSEER, which are two agronomically and environmentally important nutrients modelled in OVERSEER (Selbie et al. 2013). A simplified version is presented of the modelling steps taken for N and P loss for a pastoral farming system, using an example of the main sources and factors influencing loss for each nutrient in terms of the magnitude of loss. In many New Zealand farming systems, other sources and factors influencing nutrient loss are important, however, these are omitted here for simplicity.

5.1.1 Nitrogen – estimating N leaching from a pastoral block

In New Zealand pastoral farming systems, the excreta deposited by grazing animals (sheep, cattle and deer) is the primary source of N leaching loss. Urine and dung patches contain large N loads (up to 1000 kg N/ha), and the N in urine is rapidly converted to nitrate, a highly mobile form of N, and therefore is more prone to leaching loss. In this section, we focus on the sequence of steps used in OVERSEER to calculate N leaching loss from animal excreta deposited onto a pastoral block. As a result, other N sources of N leaching which may be important in individual situations, e.g., N mineralisation following cultivation, as well as N leaching from un-grazed areas e.g., laneways, are ignored in this example. In OVERSEER reports 'N loss to water' is made up of a series of individual components (Table 6). Nitrate-N is the main form of N captured by OVERSEER plus some allowance for dissolved organic N (DON).

Table 6: Individual components of reported 'N loss to water' in OVERSEER from a pastoral block.

Reported title under 'N loss to water'	Description	Relative importance (to magnitude of N loss to water)
Leaching – urine patches	Leaching of N from urine patches. N moved beyond 60 cm root zone (defined as farm boundary). Does not account for any transformations of N after this point (e.g., between leaving the root zone and receiving water body, collectively termed 'attenuation')	Major in a grazed pasture block. In a crop block, depends on the crop type and timing of grazing.
Leaching - other	Leaching of N from inter-urine areas and incorporates effects of dung, fertiliser, effluent and soil organic matter mineralisation. N moved beyond 60 cm root zone (defined as farm boundary). Does not account for any transformations of N after this point (e.g., between leaving root zone and receiving water body, collectively termed 'attenuation').	Minor for a grazed pasture block, (less than 15% of total N loss). Can be significant on pastoral blocks where effluent is applied. On crop blocks, generally the major source.
Runoff	Removal of nutrients from the land via overland flow.	Minimal (certain situations)
Direct (animals, drain)	Nutrient deposited directly by beef or dairy animals into streams and/or drains i.e. when stock are not excluded from waterways and discharge from	Direct deposition is minimal. On artificially drained blocks, a high proportion of N lost is via drains (shifts from leaching to loss via drains).

	mole tile drainage systems.	
Direct pond discharge	Nutrients discharged directly from effluent ponds into waterways.	Minimal (certain situations)
Border dyke outwash	Nutrients discharged in irrigation outwash from border-dyke systems (i.e. surface runoff caused by irrigation).	Minimal (certain situations)
Septic tank outflow	Nutrients discharged from septic tank outflow.	Minimal (certain situations)

OVERSEER estimates of N leaching from a grazed block can be split into five general steps: (1) Animal intake, (2) Excretion, (3) Distribution, (4) Proportion leached and (5) Scaling (Figure 5).

(1) Animal intake

The Metabolic sub-model first provides an estimate of the animal's total metabolic energy (ME) requirement for maintenance, growth and production. The Animal intake sub-model estimates how much of this total ME requirement (mega-joules of metabolisable energy, MJME) is met by supplement and crop intake, and by difference, pasture. User-entered information entered into OVERSEER supplies data on the amounts and timing of feeding of supplement and crops. Next, pasture quality is used to estimate pasture DM intake. The pasture DM intake is combined with the nutrient contents of the feed, to provide an estimate of total animal DM intake and nutrient intake (Animal intake sub-model). Feed characteristics are derived from two databases: pasture characteristics and supplement characteristics.

Note that the use of energy requirement to calculate dry matter intake based on feed energy content in OVERSEER is a different approach from what might be expected, (e.g., calculating dry matter intake based on the amount of pasture grown and fed is another way). The OVERSEER approach means that the level of production entered has an important effect on the calculation of feed (and nutrient) intakes.

(2) Excretion

The Excretion sub-model uses an animal N balance, where N excreted is N intake less N in product. Product N is used what is used to produce the product and includes N used to produce live weight gain and milk during animal growth and lactation. Product N is estimated using a combination of user inputs, other sub-models (e.g., live weight gain) and scientific literature on the N content of animal products. Note that N removed as product from a block is the N removed in milk or live weight sold. The N in live weight sold may be gained over several years. Total N excretion is then partitioned between urine and dung based on dietary N content, with the partitioning based on scientific literature.

(3) Distribution

Distribution of excreta is an important part of the N model as it uses input information to determine where and when excreta-N is deposited around the block and farm. Key steps in determining N distribution are:

- Accounting for transfers (nutrient eaten in one place and distributed in another).
    - Allocation of excreta-N to farm structures (dairy shed, feed pads, lanes) using time-based formulae,
    - Accounting for transfers between blocks and farm structures (e.g. nutrients fed in-shed but deposited as excreta on the block, or nutrients eaten on a block and but excreted on the wintering pad).
- Excreta deposited on wintering pads (place of consumption).
- Remaining excreta N is assumed to be deposited on the blocks where the animals are grazing. This is done by assuming that the distribution to blocks is based on feed consumption in each block.

The final outcome of the Distribution sub-models is an estimate of the amount of N as dung, urine and effluent deposited on each block, each month. The nutrient deposited on farm structures (e.g. wintering pads) enter the effluent management sub-model, where the nutrients may be applied back onto a block as effluent. The calculation for the proportion of N leached combines this quantity of N deposited on a block with an estimate of leaching risk or ‘proportion leached’.

(4) Proportion leached

Nitrogen leaching is modelled from urine (urine patch sub-model) and non-urine (background sub-model) areas. Both models are based on a transfer co-efficient approach which uses drainage to estimate the proportion of the ‘available’ N that is leached. A good estimate of drainage is essential to utilise the transport coefficient/drainage model approach to N leaching. Drainage is based on a daily soil water balance model which is up-scaled to a monthly time step for the monthly N model calculations. A database of typical long-term regional rainfall distributions is used for this purpose.

- *Leaching of N - Background*
    - Estimates the proportion of available N that is susceptible to leaching. Available N is the net difference between inputs from dung, fertiliser, soil, effluent and irrigation sources, and removals (N uptake, volatilisation and denitrification).
    - Assumes that the pasture behaves according to a cut and carry system, which is generally characterised by efficient pasture uptake of available N and low N leaching loss.
- *Leaching of N - Urine patch*
    - Estimates the proportion of deposited urine N that is susceptible to leaching using a N balance approach where multiple processes remove available N.
    - Removal processes must be estimated adequately: uptake, ammonia volatilisation, and nitrous oxide emissions/denitrification.
    - A transport mechanism is used to model N moving below the root zone.

(5) Scaling

For the urine patch model, the model estimates the amount of N deposited per block per month (for each animal enterprise). The model requires the proportion of N deposited in a given month that is leached, however the N that is leached can occur in any month (rarely the month of deposition), and in some situations the following year. This proportion varies with the month of deposition. In order to scale N leaching loss to the block level, the estimate of N load from urine and non-urine sources (Steps 1-3) is multiplied by the proportion of N leached each month (from Step 4).

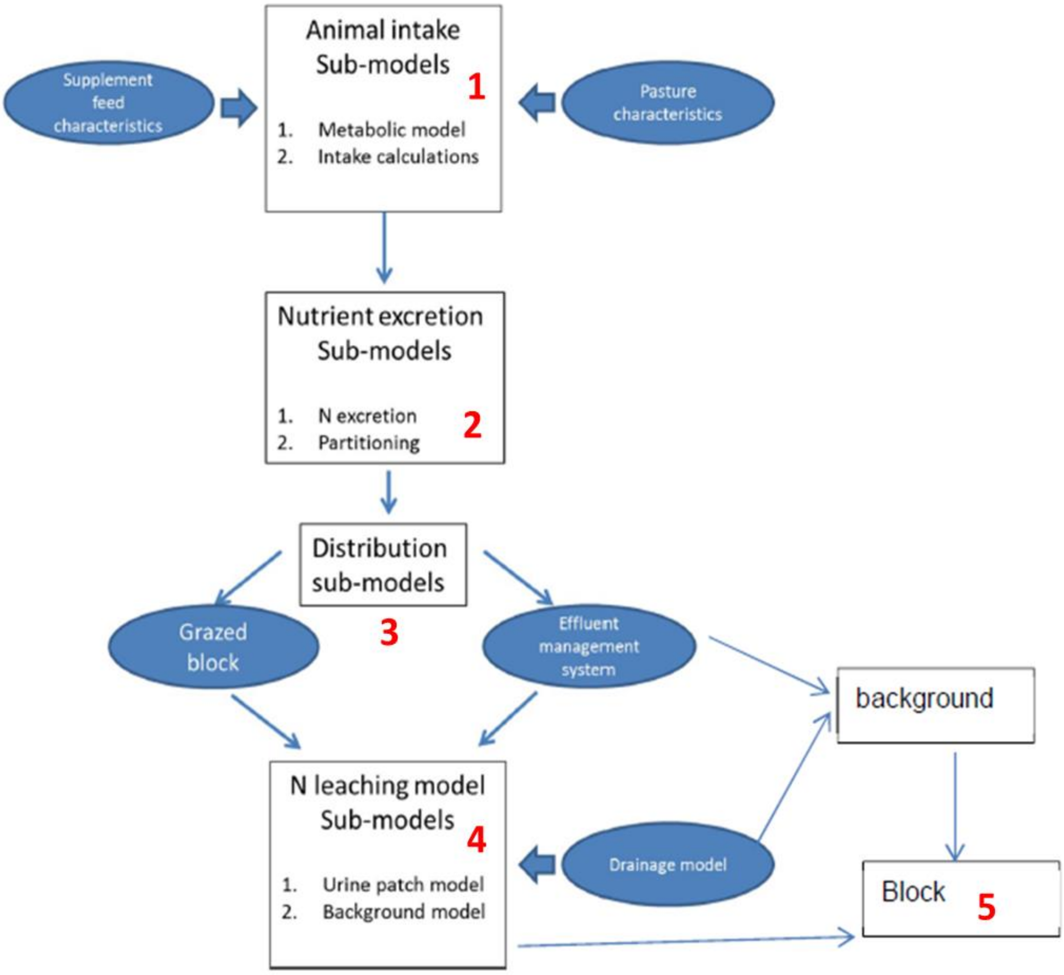

Figure 5: Calculation sequence for estimating N leaching from a grazed pasture block.

5.1.1.1 N leaching from non-grazed blocks

Non-grazed pastoral blocks can also contribute significant N losses to water. A monthly N balance estimates available N (source) potentially leached, and transport (drainage). Leaching can be large when a large amount of available N from the monthly N balance corresponds with high drainage. The primary drivers for N leaching from a non-grazed block are:

- Amount and timing of inputs (e.g., fertiliser, effluent application),
- Crop removal (affected by age, level of maturity, fallow period),
- Native/resident soil organic N (e.g., affected by years in pasture), and
- Residues (e.g., roots and stover).

In cropping regimes, much of the N in the soil is derived from mineralisation of soil N. The amount of soil organic matter that is mineralised is a function of the amount and quality of organic matter. The model uses the number of years in pasture over the previous 10 year history to estimate this. This reflects the soil organic N accumulation during the pasture phase, i.e. the longer in pasture, the greater the N release.

Accumulation of N in the soil N pool results from the process of mineralisation, derived from:

- Residue roots and stover from previous crops, with the amount dependent on roots, harvest index, and the fate of crop residues, and the fate on the N content of the residue. If the previous crop is pasture, the N from mineralisation of pasture roots and stover can be a significant contributor to the soil available N pool.
- Soil organic matter – Native N released from soil organic matter. The mineralisation rate of soil organic matter is increased, typically for 2-3 months, after cultivation, resulting in significant N release.

The amount of soil N that is susceptible to leaching is N added, including that from mineralisation, fertiliser and effluent additions, and N removal, such as uptake, volatilisation and denitrification. N uptake is determined by the crop characteristics such as yield, when growing, whether there is a ripening or drying stage. Hence, timing of inputs and crop management are important determinants of the amount of N that is potentially leached.

5.1.2 Phosphorus – estimating P runoff loss from a pastoral block

Phosphorus losses from New Zealand farming systems can be estimated as the interaction between sources of P and overland transport mechanisms, which are modified by management. Modelling of P loss is markedly different to that of N due to the importance of overland flow transport mechanisms driving P losses (topography, rainfall intensity), whereas important drivers for N are source and timing of N inputs, and drainage as the transport mechanism. P loss is modelled using a P loss 'risk' approach. As the P loss risk model has been calibrated against catchment studies, it includes P loss from farm critical source areas (CSA). However, OVERSEER does not specifically model individual CSA on a farm and the connectivity of a given CSA to water. P losses to water in OVERSEER are calculated for each block under the following categories:

- Runoff (background and incidental P loss)

- P loss through animals having direct access to streams and from drains
- Direct discharge from ponds (2-pond systems)
- P loss through system losses such as border dyke irrigation
- Septic tank outflow

Runoff in OVERSEER is defined as being either surface flow, interflow or subsurface flow (inclusive of leaching that is not partitioned to deep drainage to groundwater) up to second order streams (a stream that has two first order tributaries). P runoff loss is estimated as the sum of dissolved and particulate P forms, or 'total P' resulting from an overland flow event. Generally, for a flow event to occur a surplus of precipitation (rainfall and/or irrigation) must exist. P loss in OVERSEER is the loss from a given source (e.g. block) to the stream boundary only. This stream boundary may not be on the block or farm. Specific P loss not modelled by OVERSEER includes stream bank erosion and mass flow, which can be additional major contributors to P loss.

Sources

The model separates P losses into sources: background (soil) and incidental (effluent and fertiliser) (Figure 6). Background P losses arise where P has been released from the soil, and is lost in flow events occurring through the year. Incidental P losses are based on an assessment of the probability of a flow event occurring when there is a risk of P losses from incidental inputs.

Transport factors

Background and incidental losses are calculated separately in the model, but rely on the same transport factors affecting movement from the landscape to streams, such as rainfall, overland flow potential and topography. Rainfall is an important factor affecting P loss to streams, in particular when precipitation (rainfall plus irrigation) exceeds the soil infiltration rate and overland flow results. The potential for overland flow is derived from characteristics of soil: drainage class and a slaking/dispersion index. OVERSEER estimates the effect of topography (a key driver of P runoff loss) using a subjective weighting to separate slope classes from flat to steep.

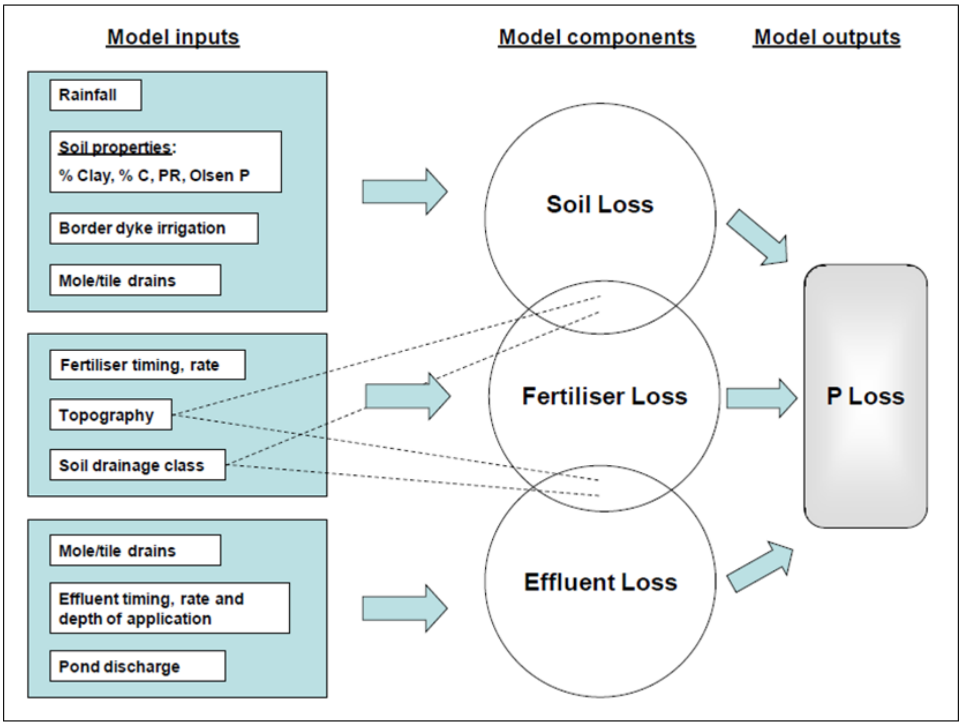

Figure 6: Conceptual diagram of P loss model structure.

Management factors

Management factors for Background losses include Olsen P status and anion storage capacity (ASC), treading by grazing animals, and erosion from fence line pacing and deer wallows, which increase soil susceptibility to P runoff. A ranking for risk of P loss is used to account for the higher probability of overland flow events to occur, based on region and month of the year.

Management factors for Incidental losses include the concentration, rate and timing of fertiliser/effluent application, the type of P fertiliser applied, and the speed of effluent application. Generally, P input application rates (kg P/ha) are multiplied by hydrologic and topographic factors that determine the potential for P runoff loss. For effluent application, management system factors (e.g., application method, depth and form of effluent) are also included.

Other P sources include P in animal dung (P intake less P in product), direct addition to streams (based on topography risk categories), lanes, silage stacks, pads and shelters, septic tank discharges. In terms of scaling from block to farm level, block P losses are aggregated using an area weighted average to a farm estimated loss, and then farm scale losses are added in. Farm scale losses include direct deposition of P from farm structures and laneways/races and P loss from ponds.

6. Limitations and Scale

All models have limitations. Limitations of OVERSEER as a strategic management tool include:

- The OVERSEER boundary is the farm boundary (which does not need to be spatially contiguous), and the bottom of the root zone (60 cm). Exceptions include greenhouse gas (GHG) emissions, such as embodied CO_2 and indirect N_2O emissions.
- OVERSEER does not interpret the effect of model outputs or fate of lost nutrients, for example OVERSEER does not report the environmental impact on water quality of nutrient loss from the farm system nor does it produce a fertiliser plan based on fertiliser nutrient maintenance requirements.
- OVERSEER does not account for the transformations of N that can occur between when a nutrient leaves the farm or root zone and enters a receiving water body (vadose zone).
- OVERSEER does not model within-stream processes that occur within the farm boundary, for example within stream attenuation, or stream bed erosion. Attenuation due to denitrification from wetlands and removal of P in overland flow by riparian strips can be included.
- OVERSEER does not model transition periods from one farm system to another, for example if the farm changes its fertiliser to a slow-release fertiliser, OVERSEER assumes that the slow-release fertiliser is operating effectively at the time it is entered into OVERSEER – that is the production achieved is commensurate with the fertiliser inputs. The same principles apply to organic systems.
- OVERSEER is not a spatially explicit model and therefore does not take account of specific critical source areas (CSA) on a farm. CSA are defined as a landscape feature (e.g. gully, depression) that accumulates overland flow from adjacent areas and delivers that overland flow to surface water bodies.
- OVERSEER does not include loss of sediment due to mass flow or stream bank or stream bed erosion or loss of *Escherichia coli* (E.coli) or other microbes and pathogens.

- OVERSEER does not represent all farm systems, management practices or combinations that occur within New Zealand.
- OVERSEER assumes that effluent is applied in the month it is produced or selected as being applied (deferred effluent applications), and that within the month, effluent is applied in such a manner as to minimise losses, including the use of storage facilities.
- OVERSEER has not been validated against every combination of environment and farm enterprise (note that this is a limitation of every model). OVERSEER attempts to represent the various combinations based on scientific principles so that estimates can be made.

The limitations listed above highlight that OVERSEER should be frequently used in conjunction with other models, farm or nutrient management plans and rural professionals to fully interpret the outputs.

7. Assumptions

The assumptions and design criteria of any model is critical for the correct use of a model and interpretation of its outputs. Key assumptions in OVERSEER arise from its design, development and overall purpose and are described in Table 7.

Table 7: Key assumptions in OVERSEER that are important for correct model use and interpretation of reported information.

Assumption (or boundary condition)	Explanation	Example
Use data that was available	One of the objectives of OVERSEER was that data inputs were based on information farmers had readily-available, or based on suitable defaults.	Supplying daily climate data for a given location in New Zealand is not realistic, so suitable alternatives are provided[*]
Animal production to get pasture production	Given this assumption, when undertaking 'what if' analysis, the farm production data needs to be adjusted if any input data is changed.	Reducing N fertiliser inputs might result in reduced feed supply and consequently productivity. OVERSEER is a reporting tool and records the farm as set-up, so the user needs to adjust the input information accordingly to ensure the farm system remains feasible.

Steady-state conditions ('quasi-equilibrium')	Quasi-equilibrium means "Inputs and site characteristics are in equilibrium with farm production and stock policy (stock numbers, breeding performance, crop yields etc.)".	For organic systems, the model assumes that the farm production achieved is commensurate with fertiliser inputs.
Actual and reasonable inputs	Input data actually represents the farm system and input data are sensible. This is a consequence of the quasi-equilibrium assumption. OVERSEER does not consider whether a farm is viable, rather it assumes that a farm is viable for the given inputs and farm production.	Entering an unrealistic farm system or using input data that are not representative. e.g., Dairy cows on high country blocks, Kikuyu pastures in Southland
Annual average outputs	The model estimates annual average outputs assuming that management, inputs and farm production are constant for the given site-specific characteristics.	A research trial will likely produce different N leaching measurements in each year of a 5-year study (due to site-specific conditions and management). The average N leaching for the trial duration is used (alongside other research trial data) to calibrate the model.
Good management practice (GMP) are followed	The model assumes that the farm is operating in such a way that additional effects that cannot be captured* by the model are having minimal impact on model outputs. The intention of this assumption is to capture those unseen and unknown variations in on-farm practice that occur, not to define whether or not a practice is 'good' or 'bad'. *Practices not captured by the model are where something occurs on farm but is not accounted for in the model. This is typically due to an omission from the model, or because the method to describe the practice is difficult to capture as a model input.	The model assumes the effluent irrigator is applying nutrients in the correct place, not over a drain one day and a paddock the next. The model assumes that dairy cows use laneways to move from the paddock to the milking shed.

[*]The default climate data that is supplied with the model is:

(1) Climate tool that provides 30-year average annual rainfall, PET and temperature, or user input values can be entered.
(2) Monthly patterns for rainfall, PET and temperature based on a 30-year average monthly data for regions or nearest towns. The user can select a seasonal pattern.
(3) 15 daily rainfall patterns based on typical values extracted from 30-years of average daily climate data.

Model outputs have been calibrated against research trials. For the N leaching model, the calibration is based on climate for the duration of the trial. The model is calibrated against average annual losses – those losses measured over the duration of the trial. The above assumptions give rise to the definition of the nutrient budget, that is:

The nutrient budget is a summation of annual inputs and outputs. The outputs are the average annual losses, assuming the inputs (management) are constant over time, for the given site characteristics.

8. Uncertainty in model outputs

What is uncertainty?

The outputs of every model involve a level of uncertainty. OVERSEER was designed to accommodate the use of easily obtainable data, which means that the model uses simplifications of complex processes. The estimates resulting from these simplifications will always involve uncertainties. Actual measurement or an accepted value for farm-scale nutrient loss is practically extremely challenging and very rare (Shepherd et al 2013).

Other terms are regularly used to describe uncertainty around OVERSEER outputs such as ‘precision’, ‘accuracy’ and ‘error’. Accuracy and error are not strictly applicable to OVERSEER estimates. Precision is relevant for input information (how repeatable the data/information is). The most relevant term is uncertainty, which is a potential limitation in some part of the modelling process that is a result of incomplete knowledge.

There are multiple sources of uncertainty in OVERSEER, all with different characteristics and methods to control. Figure 7 attempts to combine these sources, in a generalised approach, by depicting the difference between measurement and modelling uncertainty.

Measured data contains the variability in space and time inherent in all biological systems, such as the differences in soil moisture measured across a paddock. Modelling uncertainty includes all the variability associated with data input as well as modelling procedures. Sources of variability in data input and modelling procedures include:

- Difference between users input of data,
- Variability in the representation of the actual farm system via data records,
- Errors in input and boundary condition data, model structure, parameter values, observations used to calibrate or evaluate, errors of omissions, commensurability of modelled and observed variables and parameters, and
- The unknown 'unknowns'.

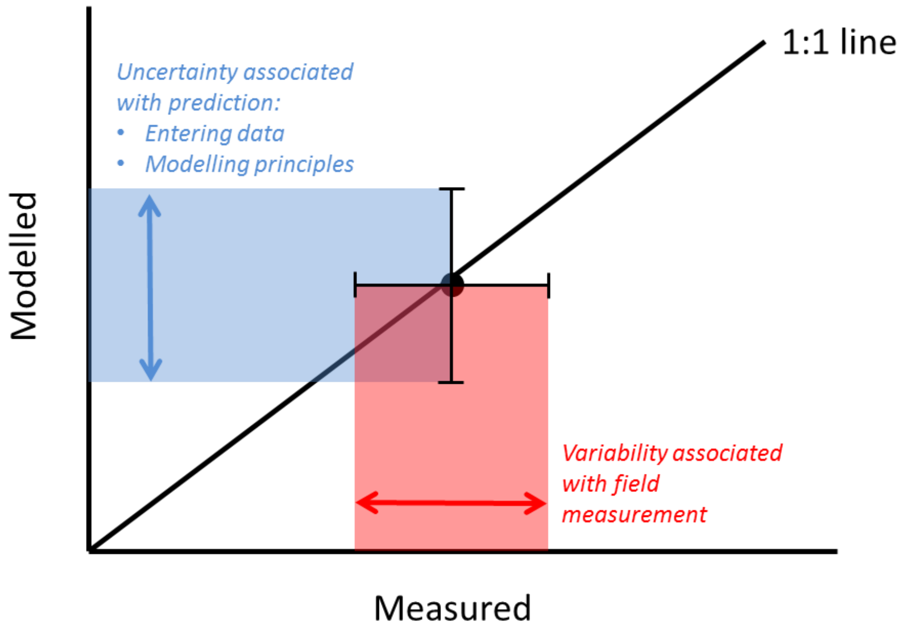

Figure 7: Conceptual example of the relationship between modelled and measured uncertainty in OVERSEER.

While the importance of the various sources of uncertainty in models can be recognised, quantifying and accounting for them is particularly challenging, especially for a model describing complex farm systems like OVERSEER. A report by Ledgard and Waller (2001) estimated uncertainty of 25-30% for model predictions for N, which has since been widely quoted. However, this estimate didn't include errors associated with measurements, or uncertainty from data inputs, providing only part of the full picture of quantifying uncertainty, and is therefore limited. Since 2001, there have been a number of changes to the model, which is likely to result in a different uncertainty estimate for the current model version. An updated uncertainty analysis could usefully be undertaken; however, quantifying all of the sources of uncertainty involved in the N leaching value produced by OVERSEER is impossible. Therefore, *reducing* uncertainty may be a more appropriate use of resources, and for which there are several options.

Evaluation process and reducing uncertainty

Best practice model evaluation involves: (1) validation, which is a *comparison* between modelled and measured, and (2) calibration, the process of adjusting model parameter values to maximise the agreement between a given set of data and the model outputs (Figure 8). All models should be calibrated. In order to provide confidence in a model, outputs can be validated ('compared') against a set of independent data (not used in calibration) (Shepherd et al. 2015). In OVERSEER, the pastoral N leaching model has been continually validated and calibrated, whereas the P loss model is based on a calibration process.

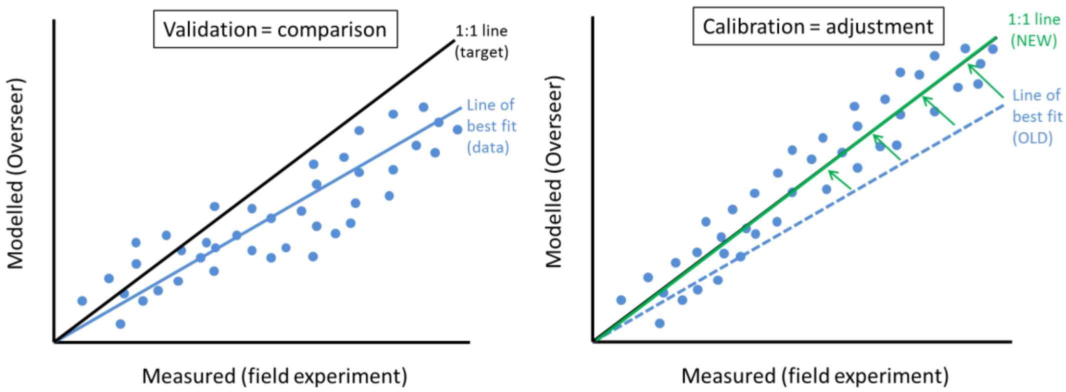

Figure 8: The model evaluation process consists of validation (comparing modelled estimates against measured values) and calibration (adjusting modelled estimates to match measured values).

While the wide range of farm systems and environments in New Zealand means obtaining data for all of these is unrealistic, continuing to source data from a greater range of systems and environments is most useful for validation and calibration and reducing uncertainty in model outputs (Figure 9). Uncertainty around model estimates tends to be lower within the range of the calibration data set i.e. where we have the most information. The model is capable of extrapolating outside of this range; however, the uncertainty is greater because there is less available information supporting the modelled estimate. A simple example is annual rainfall, whereby N leaching estimates under high rainfall (>1500 mm per year) conditions have far greater uncertainty due to the lack of measured data from these situations.

Most of the calibration data used to date is focused on flat, pastoral, dairy enterprises, with primarily free-draining soils and moderate rainfall. Therefore, to strengthen the calibration dataset and to reduce uncertainty in model outputs (from modelling process source), datasets from outside this range are required e.g., cropping, beef and sheep enterprises, clay and shallow soil types, rainfall zones > 1200 mm.

Opportunities to reduce uncertainty in OVERSEER outputs:

- Using Best Practice Data Input Standards, improving data inputs and default values
- Improving the understanding and description of farm systems,
- Using best practice evaluation, validation and calibration processes, including:
    - Increasing the number of datasets of field measurements that sit outside the existing/typical calibration dataset range e.g., high rainfall, clay soils, enterprises other than pastoral/grazed.
    - Continually increasing the number of farmlet scale datasets for use in validation and calibration.
    - Developing and using best practice guidelines for scientific measurements and data accumulation, as well as science-model integration (translating scientific information into the existing model).
    - Linking to systems such as daily management monitoring.
    - Model comparison and inter-modal scale comparisons.

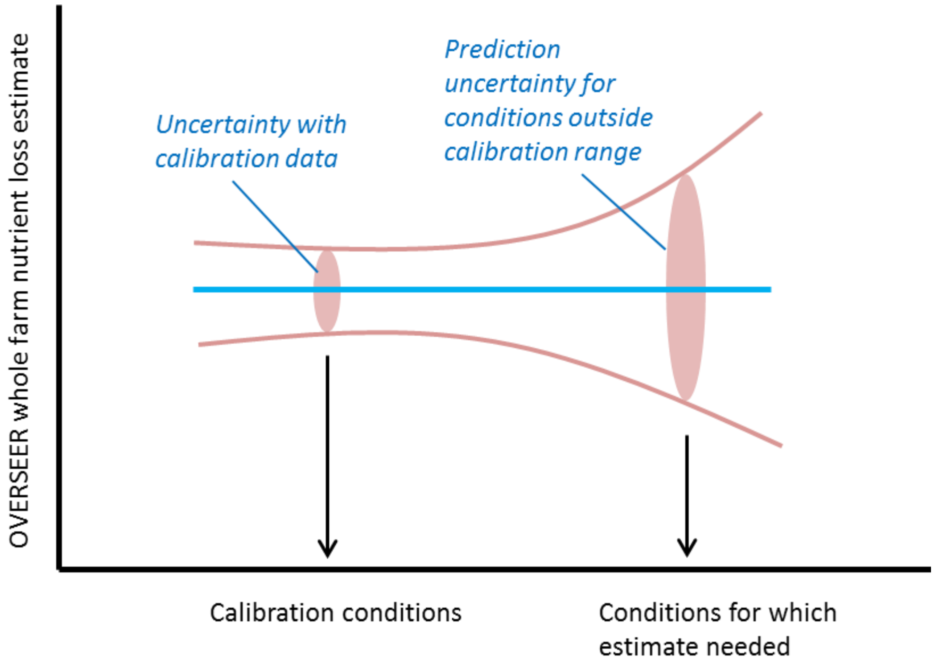

Figure 9: Schematic description of the uncertainty associated with model prediction outside the range of calibration data.

9. Sensitivity analysis

The sensitivity of the model to specific inputs generally depends on the output of concern and the farm system. In general, the main inputs that have the most influence on nutrient loss estimates are:

(a) Inputs that influence the size of **source** of a nutrient (e.g., stocking rate, fertiliser inputs), and

(b) Inputs that influence the **transport** of a nutrient (e.g., soil, drainage, slope for P).

It is important to note that drainage is a key driver of N (and P) losses and it is therefore important to recognise that the calculation in OVERSEER that determines drainage is sensitive to:

- Climate inputs, predominantly rainfall, potential evapotranspiration,
- Soil characteristics that affect profile available water such as soil order, texture, sand or stony subsoils, and the depth to those subsoils, and
- Irrigation rate and method, and (less important) crop cover (Wheeler and Shepherd, 2013b).

The key inputs with the most influence on nutrient loss estimates are summarised in Table 8.

Table 8: Main inputs that have an influence on nutrient loss estimates in OVERSEER

Category	Variable	Effect on calculated		Ability of farmers to influence
		Nitrogen	**Phosphorus**	
Animal	Stocking rate	X	X	X
	Species	X		X
	Gender	X		X
	Production and Reproduction policy	X		X
	Sheep/Beef ratio	X		X
	Management	X	X	X
Fertiliser	Fert N rate	X		X
	Fert N form	X		X
	Fert P rate		X	X
	Fert P form		X	X
	Timing	X	X	X
Effluent management	Amount	X	X	X
	Timing	X	X	X
General	Rainfall	X	X	
	Irrigation rate	X	X	X
	Topography		X	
Pasture	Clover level	X		X
	Pasture type	X		X
	Pasture ME	X		X
Soil	Natural drainage	X	X	
	Artificial drainage	X	X	X
	Anion storage		X	
	Soil properties	X	X	
	Olsen P		X	X
Supplements	Farm grown supplements	X		X
	Imported supplements	X		X

Crops	Type	X	X	X
	Management	X	X	X

Sensitivity analysis can provide a qualitative and quantitative indication of which model parameters or attributes of the farm system have the greatest influence on the size of an output such as N leaching. However, the results should be interpreted with caution as they tend to be carried out within narrow constraints e.g., not representative of the full range of farm systems and environments, or including potentially important drivers.

10. Other sources of information

OVERSEER software is freely available in New Zealand and may be accessed via the OVERSEER website www.overseer.org.nz. To access OVERSEER you need to create a MyOVERSEER account by clicking on the 'Getting Started' button on the website. The 'MyOVERSEER' portal provides users with access to the Online and Standalone versions of OVERSEER. MyOVERSEER and the OVERSEER website provide access to a number of information sources, including:

- Helpdesk service (logging issues, asking questions, making suggestions)
- Release notes (supporting information for upcoming model version releases)
- Best practice Data Input Standards (document providing guidance around inputs into OVERSEER to reduce inconsistencies between different users when operating OVERSEER)
- Technical notes (additional technical information on specific topics)
- Technical manual chapters (detailed technical description of sub-models)
- Science papers and reports (published information relating to Overseer use, evaluation and underpinning science)
- OVERSEER news.

The OVERSEER website is main platform for communicating with the users and for users to provide feedback. To learn more about OVERSEER, OVERSEER Management Services Limited offers an introductory course in OVERSEER. Registration of interest for courses is via the website. Massey University also provides two short courses (Intermediate and Advanced) in Sustainable Nutrient Management. These courses use OVERSEER to illustrate principles in nutrient management. It is recommended that anyone providing advice on the outputs of OVERSEER or carrying-out 'what if' mitigation scenarios is a certified 'Nutrient Management Adviser. More information around becoming a certified Nutrient Management Adviser can be accessed via the website www.nmacertification.org.nz.

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12. References

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